Geol Survey

Guide to the geology of the Savanna area, Carroll and Jo Daviess Counties

David L. Reinertsen

Field Trip Guidebook 1989B May 20, 1989
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, IL 61820

Cover photo: "Twin Sisters" rock formation, carved in Silurian bedrock by erosion, is about 0.3 mile south of Mississippi Palisades State Park main entrance.

Title page: Silurian rocks exposed in bluff of Mississippi Palisades State Park. View is south from near Louis Point. Savanna-Sabula Bridge across Mississippi River in right background.

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GEOLOGIC FRAMEWORK OF THE SAVANNA AREA

Surficial deposits

The Savanna area lies along the towering, spectacularly carved east bluffs of the Mississippi River valley in northwestern Illinois. Most of the field trip area was not buried under the massive, slow-moving continental glaciers or ice sheets during the geologically recent Ice Age. This area, apparently unglaciated, covers about 10,000 square miles and extends northward into southwestern Wisconsin; it is called the "Wisconsin Driftless Section" (fig. 1).

Figure 1 Physiographic divisions of Illinois.

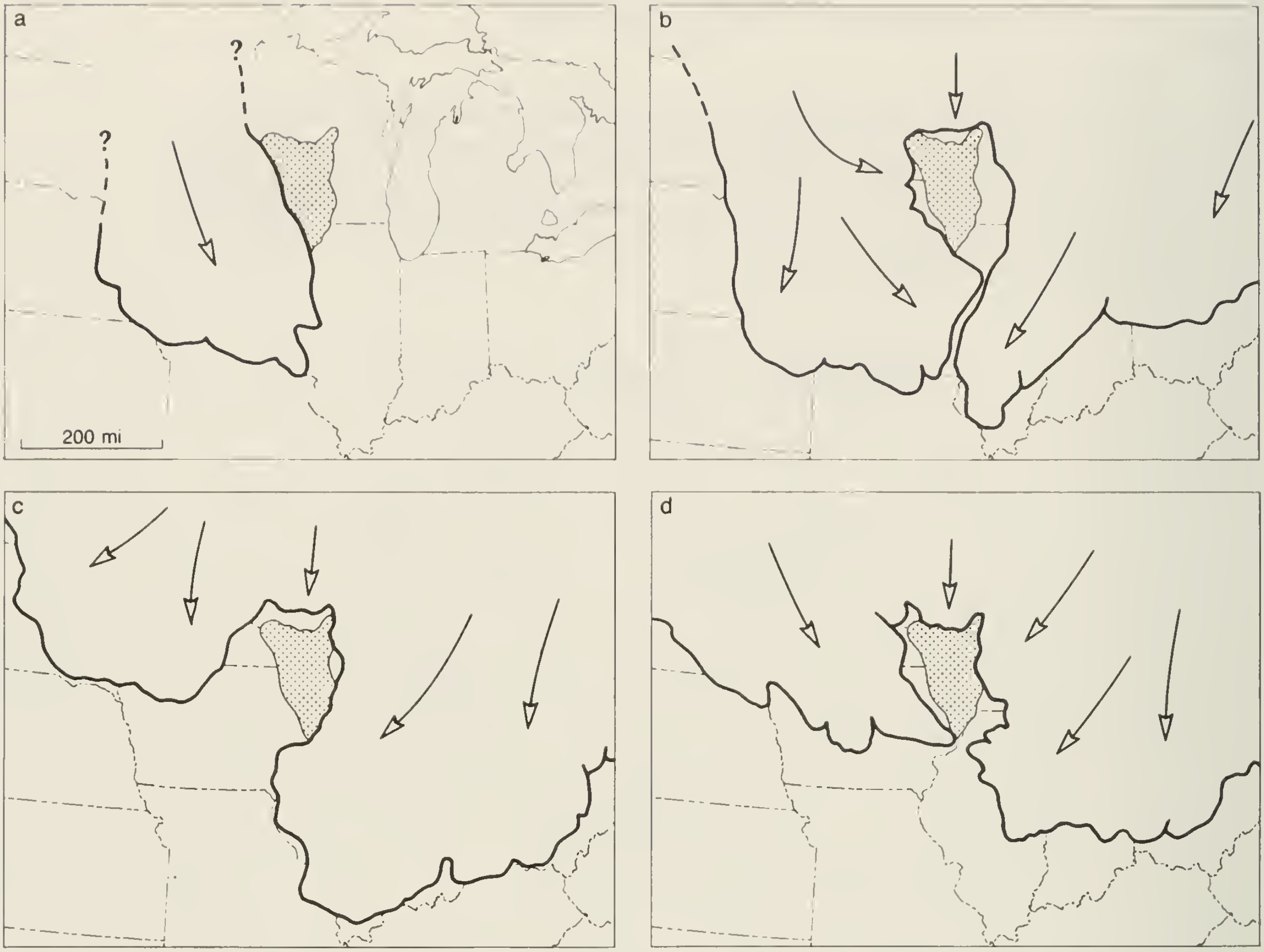

Figure 2 Maximum extent of *a)* early Pre-Illinoian glaciation (1,000,000± years ago); Driftless Area shown by stippled pattern; arrow indicates direction of ice movement; *b)* late Pre-Illinoian glaciation (600,000± years ago); *c)* Illinoian glaciation (250,000± years ago); *d)* late Wisconsinan glaciation (22,000 years ago).

The time of widespread continental glaciation known to geologists as the Pleistocene Epoch lasted in Illinois from at least 1.6 million years ago until about 10,000 years before the present (B.P.). Glaciers of Illinoian age covered the southeastern part of the field trip area (see route map on back cover) nearly 250,000 years B.P. The last ice sheet melted away from an area east of the field trip during Wisconsinan time, around 20,000 years B.P. (see *Pleistocene Glaciations in Illinois* in appendix).

Although ice sheets covered parts of Illinois several times during the Pleistocene Epoch, it was during Illinoian glaciation (from perhaps 300,000 to 175,000 years B.P.), that North American continental glaciers reached their southernmost extent, advancing from centers of snow and ice accumulation in Canada as far as the northern part of Johnson County in southern Illinois. Illinoian glaciers built morainic ridges similar to those of the later Wisconsinan glaciers, but Illinoian moraines apparently were not as numerous and have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. Consequently their topography is generally less well defined.

The easternmost point of the Savanna area field trip is about 25 miles northwest of the nearest deposits left by the younger Woodfordian (Wisconsinan Stage) continental glaciers some 20,000 years B.P. Although glaciers did not cover most of the field trip area nor completely surround it at any one time during the major ice advances (fig. 2), outwash deposits of silt, sand, and gravel were dumped along the Mississippi Valley. When these deposits dried out during the winters, strong prevailing winds from the northwest winnowed out the finer materials, such as fine sand and silt, and carried them eastward across the unglaciated terrain. This windblown silt called loess (pronounced "luss") also blankets the poorly sorted till or ground moraine (glacial drift) left behind by the glaciers that covered much of the rest of Illinois at one time or another during the Pleistocene. Loess thicknesses between 20 and 25 feet have been reported in areas adjacent to the Mississippi River. The loess thins to the east.

Physiography

The Wisconsin Driftless Section, or "Driftless Area" as it is commonly called, has some of the most rugged topography in Illinois. The deeply dissected, low plateau is bounded by the outwash-filled valley of the Mississippi to the west and the Illinoian glacial margin on the east and southeast. Only loess, in which the modern soils developed, mantles the deeply dissected bedrock surface. Remnants of the upland surface remain, but most of the area slopes rather steeply toward the streams. Topography in the adjacent glaciated area of the Rock River Hill Country (fig. 1) is more subdued than in the Driftless Area. Here the thin Illinoian glacial deposits--which barely mask the irregularities of the major uplands and valleys formed by Pre-Illinoian erosion of the bedrock--have produced a rolling landscape. The major streams are flowing in rather broad, steep-walled valleys, and relatively flat upland areas still remain. Major streams flow from a central upland westward to the Mississippi River and eastward and southward to the Rock River. Alluvium, relatively modern deposits along the streams, has been eroded, leaving terraced remnants along the valley walls.

Drainage

The Mississippi River is the major drainageway in northwestern Illinois. Major tributaries in the field trip area are the Plum River and Camp, Johnson, and Rush Creeks (fig. 3); these tributaries generally flow south and west into the Mississippi River. Most additional drainage occurs through a well-developed network that has grown headward into the upland remnants through a series of smaller, V-shaped tributaries with steep gradients. Some of the minor tributaries have incised meanders (fig. 10). Considerable subsurface drainage occurs through small caves and channels that have developed in the dolomitic bedrock strata.

Relief

The highest point along the Savanna field trip route is in the northernmost part of the area at the intersection of Ridge/Derinda and Heer Hill Roads (mileage 11.35+), where the surface is 952 feet above mean sea level (msl). The lowest point is the Mississippi River surface, which has a normal pool elevation of 583 feet msl upstream from Lock and Dam No. 13 at Clinton, Iowa. The regional relief is therefore approximately 369 feet. Local relief is most pronounced along the Mississippi River Palisades where it is about 225 feet.

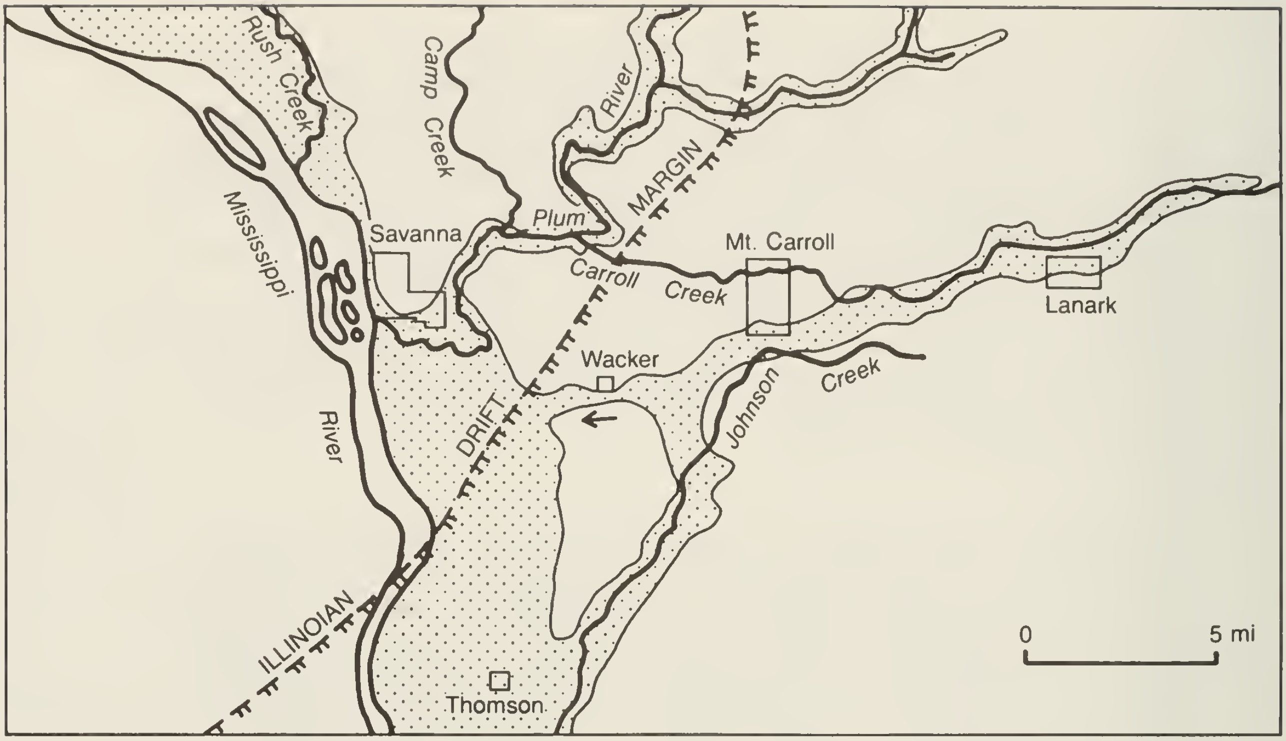

Figure 3 Pre-Illinoian bedrock valleys (stippled) of the Mississippi River and present major tributaries in the Savanna-Mt. Carroll area. Arrow indicates a possible Illinoian meltwater spillway. (Modified from Horberg, 1950.)

Bedrock

The bedrock layers (strata) below the glacial deposits in the Savanna area consist of about 2,800 feet of lower Paleozoic limestone, dolomite, sandstone, and shale ranging in age from Croixan (late Cambrian) to Niagaran (middle Silurian). Only the upper 500 to 600 feet of these early strata are exposed in the Savanna field trip area. Nearly 2,200 feet of these strata occur below the units illustrated in figure 4. These older rocks, which do not crop out in this vicinity, are known from samples recovered from deep wells in adjacent areas and from rock exposures farther north where they rise to the surface toward the Wisconsin Arch (fig. 5). These marine sedimentary rocks were formed from ancient sediments deposited layer upon layer in shallow seas. The seas repeatedly covered the Midcontinent region during the early part of the Paleozoic Era from about 550 to 400 million years ago. The base of the Cambrian rocks rests upon ancient igneous and metamorphic crystalline rocks of Precambrian age that form the so-called "basement complex." In Illinois, these ancient rocks range from 640 million to nearly 1.4 billion years old, according to radiometric dating. Precambrian rocks crop out at the earth's surface around the upper Great Lakes and in Canada. Pieces of these exposed rocks were carried into the field trip area by Ice Age glaciers.

Younger Paleozoic sedimentary strata of the Devonian, Mississippian, and Pennsylvanian Periods occur farther to the south (see Geologic Map in the back of this publication). Rocks of these ages may also have been deposited in the Savanna area, but if so, they were removed by later erosion. Pennsylvanian strata rest upon rocks as old as Ordovician age in several places in northern Illinois, indicating that considerable erosion occurred before the beginning of the Pennsylvanian Period.

SYSTEM	SERIES	GROUP	FORMATION Thickness, ft	LITHOLOGY	DESCRIPTION
SILURIAN	NIAGARAN		Racine 300		Dolomite, pure, gray, thin-bedded to massive; local reef structures; local areas of brownish gray, argillaceous dolomite.
			Marcus 35-45		Dolomite, very pure, buff, vesicular, massive; contains *Pentamerus* in great abundance in lower 5-15 ft.
	ALEXANDRIAN		Sweeney 45-55		Dolomite, pure, pinkish gray; in thin wavy beds with green shale partings; corals abundant; 3-5 ft cherty zone near middle contains *Microcardinalia* and *Pentamerus*.
			Blanding 25-35		Dolomite, pure, brownish gray; contains many layers of white chert; silicified corals abundant; lower 3-5 ft slightly argillaceous.
			Mosalem 6-60		Dolomite, gray, cherty, medium-bedded; lower part is very argillaceous dolomite grading to dolomitic shale at base.
ORDOVICIAN	CINCINNATIAN	Maquoketa	Brainard 0-50		Shale, greenish gray, dolomitic; interbedded with fine- to medium-grained, argillaceous dolomite; abundant and diverse fauna consisting largely of brachiopods and bryozoans.
			Fort Atkinson 0-10		Dolomite, yellowish gray, fine-grained, argillaceous, thin-bedded; interbedded with greenish gray shale.
			Scales 125		Shale, gray, dolomitic; conchoidal fractures; *Isotelus* common in upper part; dark brown, carbonaceous, laminated shale in lower 15 ft; one or two beds of brown argillaceous dolomite at base containing depauperate fauna, pyrite, and phosphatic pebbles.

Figure 4 Stratigraphic column from the top of the Niagaran (middle Silurian) to the base of the Champlainian (middle Ordovician) in Carroll and Ogle Counties (from Kolata, 1976). *Figure 4 continues downward on page 6.*

SYSTEM	SERIES	GROUP	FORMATION Thickness, ft	LITHOLOGY	DESCRIPTION
ORDOVICIAN	CHAMPLAINIAN	Galena	Dubuque 30-45		Dolomite, argillaceous, light gray to buff, fine- to medium-grained, thin- to medium-bedded; brown shale partings.
			Wise Lake 70-80		Dolomite, pure, light gray to buff, medium-grained, thick-bedded to massive; abundant molluscan fauna; *Receptaculites* abundant near middle.
			Dunleith 130		Dolomite, gray to buff, medium-grained, thin- to thick-bedded; white to dark gray chalky and vitreous chert, particularly in upper part; *Receptaculites* abundant. Lower part argillaceous, sandy, fossiliferous, with green shale partings.
			Guttenberg 2-15		Dolomite and limestone, argillaceous, gray to brown, fine- to medium-grained, thin-bedded; reddish brown shale partings; abundant and diverse fauna.
		Platteville	Quimbys Mill 12		Dolomite, slightly argillaceous, light gray to buff, fine-grained, thin- to medium-bedded.
			Nachusa 20		Dolomite, pure, light gray to buff, thick-bedded, medium-grained, vuggy, fucoidal; white to light gray chert.
			Grand Detour 15-45		Dolomite and limestone, light gray to buff, thin- to medium-bedded, fine-grained; reddish brown shale partings; fossiliferous.
			Mifflin 15-25		Dolomite and limestone, argillaceous, light gray to buff, thin-bedded, fine-grained; greenish gray to blue-gray shale partings; fossiliferous.
			Pecatonica 20-30		Dolomite and limestone, light gray to buff, thin- to medium-bedded, fine-grained; brownish gray shale partings; corrosion surface at top; well-rounded sand grains in lower part.
		Ancell	Glenwood 5-20		Shale, sandstone, and dolomite, greenish gray; poorly sorted, fine- to coarse-grained sand.
			St. Peter 50-200		Sandstone, white, fine-grained, well-rounded, well-sorted, friable, thick-bedded to massive.

Figure 4 *concluded*

Structure
The Savanna area is northwest of the Illinois Basin (figs. 5 and 6) on the southwestern flank of the broad, gently sloping Wisconsin Arch. Here, Paleozoic bedrock strata have a gentle regional dip of 20 to 30 feet per mile to the southwest, unless affected by local structure.

The Plum River Fault Zone (figs. 7 and 8) extends westward for nearly 60 miles from Leaf River, Ogle County, Illinois, through the Savanna field trip area, to a place south of Maquoketa, Jackson County, Iowa. This zone is a narrow belt of high-angle faults in which the fault surfaces are inclined nearly 90 degrees. Bedrock strata across the fault zone have been broken and displaced vertically as much as 100 to 400 feet (fig. 8). A sharp linear boundary exists between the downthrown Silurian bedrock on the north and the upthrown Ordovician strata on the south sides of the Plum River Fault Zone (fig. 7). Faulting occurred sometime after the Niagaran (middle Silurian) sediments were deposited and before mid-Illinoian time.

A broad, shallow, east-west trending syncline (downwarp) lies north of the fault zone and parallel to it. This structure, Uptons Cave Syncline (fig. 7), is exposed along the east side of IL 84 in the Mississippi River bluffs north of the Savanna-Sabula Bridge. The structure can be seen best from near the west end of the bridge when there is no foliage to block the view. Silurian and Ordovician strata dip to the north from a point near the east end of the bridge to a synclinal axis (the lowest point of the downwarp) about 500 feet north of Uptons Cave, then rise gently northward. Subsurface data also reflect the presence of this structure.

MINERAL PRODUCTION
Of the 102 counties in Illinois, 98 reported mineral production during 1986, the last year for which complete records are available. The total value of all minerals extracted, processed, and manufactured in 1986 was $3,268,100,000, a decline of nearly $490 million from the previous year and the lowest recorded total value since 1978. In Illinois, coal continued to be the leading commodity, followed by oil, stone, sand and gravel, and clays. Illinois is ranked sixteenth among the states in production of nonfuel minerals and leads all other states in production of fluorspar, industrial sand, tripoli, and iron-oxide pigments.

Carroll County ranked eighty-seventh among Illinois counties in the value of its mineral production. Crushed and broken stone was the only mineral commodity produced in the county (figures for 1985 stone production were used for determining ranking because stone production is only reported every other year). When only two or three commodity producers operate in a county, tonnage and value figures are withheld to keep data of the individual companies confidential. Total Illinois production of crushed and broken stone (limestone and dolomite) amounted to 41,044,000 tons valued at $164,117,000.

Jo Daviess County ranked eighty-eighth among Illinois counties in the value of its mineral production of stone and common sand and gravel (1985 stone figures were used for determining ranking; sand and gravel figures are for 1986). Illinois production of common sand and gravel amounted to 27,867,000 tons valued at $82,523,000. Jo Daviess County's tonnage and value figures for these mineral commodities have been withheld to protect confidential data of the producing companies.

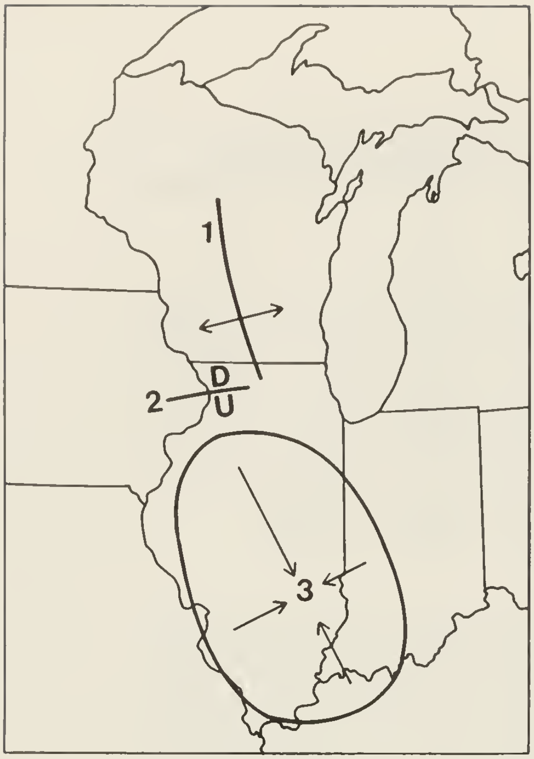

Figure 5 Index map shows locations of *1)* the Wisconsin Arch; *2)* the Plum River Fault Zone; *3)* the Illinois Basin.

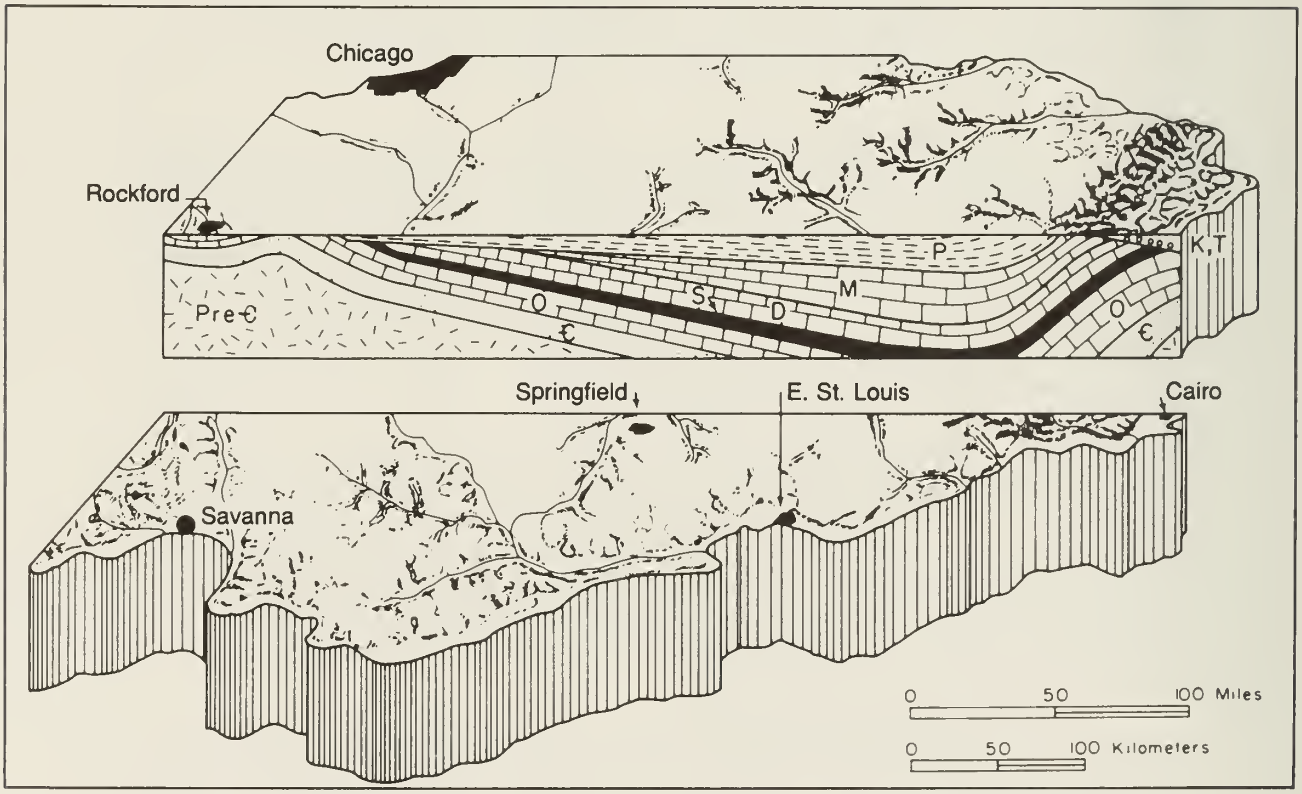

Figure 6 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-€) granites that form a depression filled with layers of sedimentary rock of various ages: Cambrian (€), Ordovician (O), Silurain (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

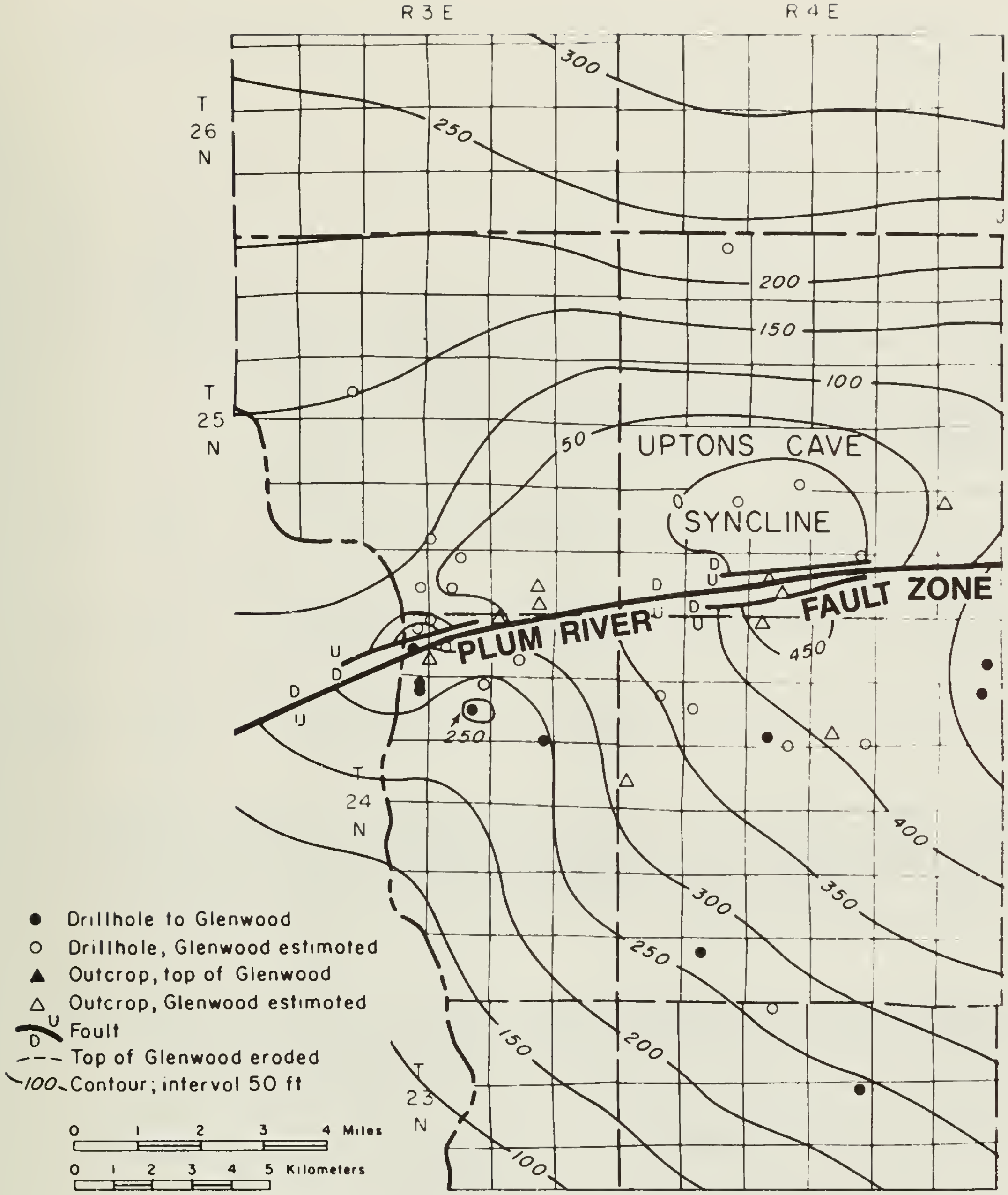

Figure 7 Structure on top of the Glenwood Formation in part of Carroll County. In some drillholes and outcrops, the top of the Glenwood was estimated from shallower horizons (modified from Kolata, 1976).

GROUNDWATER

Groundwater is a mineral resource frequently overlooked in assessment of an area's natural resource potential. The availability of this mineral resource is essential for orderly economic and community development. More than 48 percent of the state's 11 million citizens depend on groundwater for their water supply. Throughout Illinois, groundwater is derived from underground formations called aquifers. An aquifer is a body of rock that contains enough water-bearing porous and permeable materials to release economically significant quantities of water into an open well or spring. The water-yielding capacity of an aquifer can be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

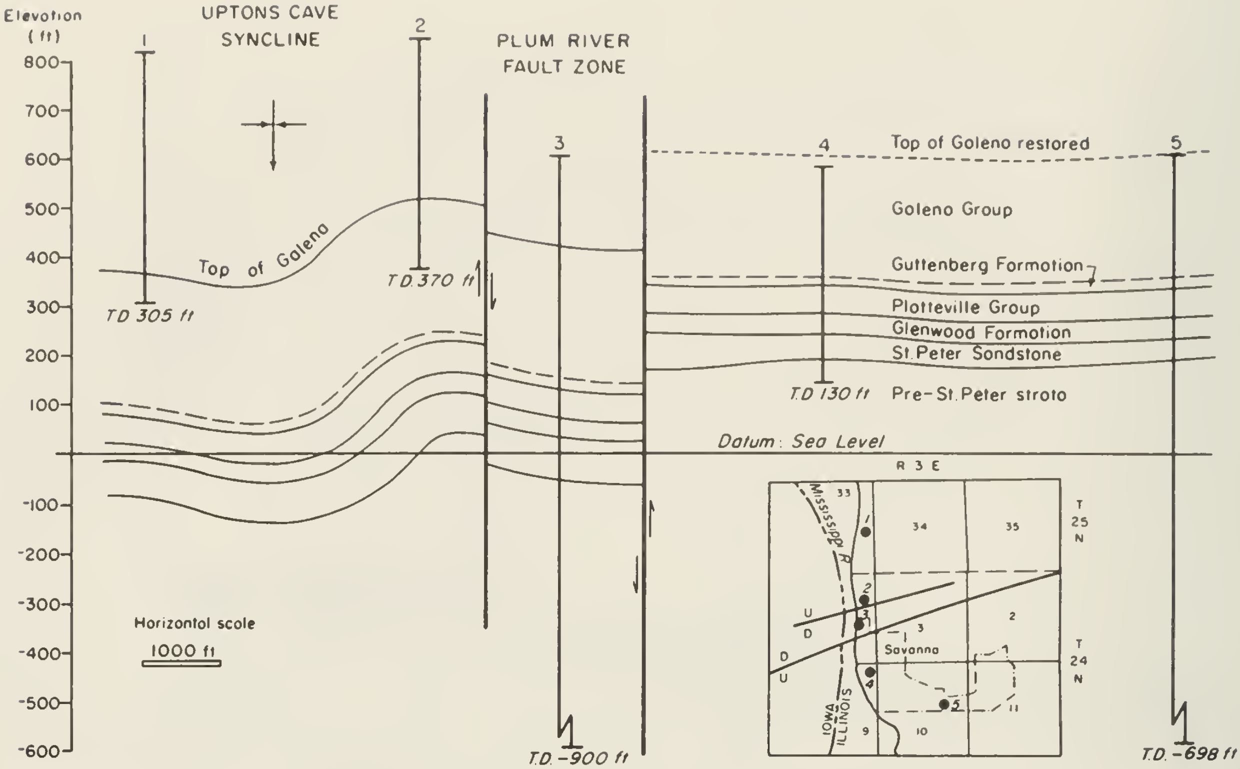

Figure 8 Structural cross section shows stratigraphic relationships in Savanna, Illinois. Interpretation is based on sample studies of five water wells (shown on inset map): *1)* Mississippi Palisades State Park well no. 2, NE NE SE sec. 33, T25N, R3E; *2)* Stransky farm well, SE NE NE sec. 4, T24N, R3E; *3)* Savanna city well no. 5, NW NE SE sec. 4, T24N, R3E; *4)* Times Theatre well, SE NE NE sec 9, T24N, R3E; *5)* Savanna city well no. 4, SE SW NE sec. 10, T24N, R3E (Kolata, 1976).

The possibilities are not good that thick or widespread sand and gravel zones containing large supplies of groundwater will be found in the thin Illinoian glacial drift south and east of Savanna. Thick permeable sand and gravel deposits occur in some places in the Mississippi Valley, and some may be found along the major tributaries of the Mississippi, especially in the lower parts of their valleys. Electrical earth resistivity surveys (a geophysical method for characterizing buried sand and gravel deposits)[1] could prove useful in locating groundwater supplies in these valleys as well as in the glacial deposits south and east of Savanna.

Silurian and Ordovician dolomite is creviced and water-bearing. Most domestic wells in the area get their water from these formations at depths of less than 250 feet. Wells into these creviced formations are susceptible to bacterial pollution, particularly where the formation is overlain by less than 35 feet of overburden (overlying earth materials). Polluted water can travel long distances through open crevices, and since little filtering action occurs in the crevices, little of the deleterious material is lost.

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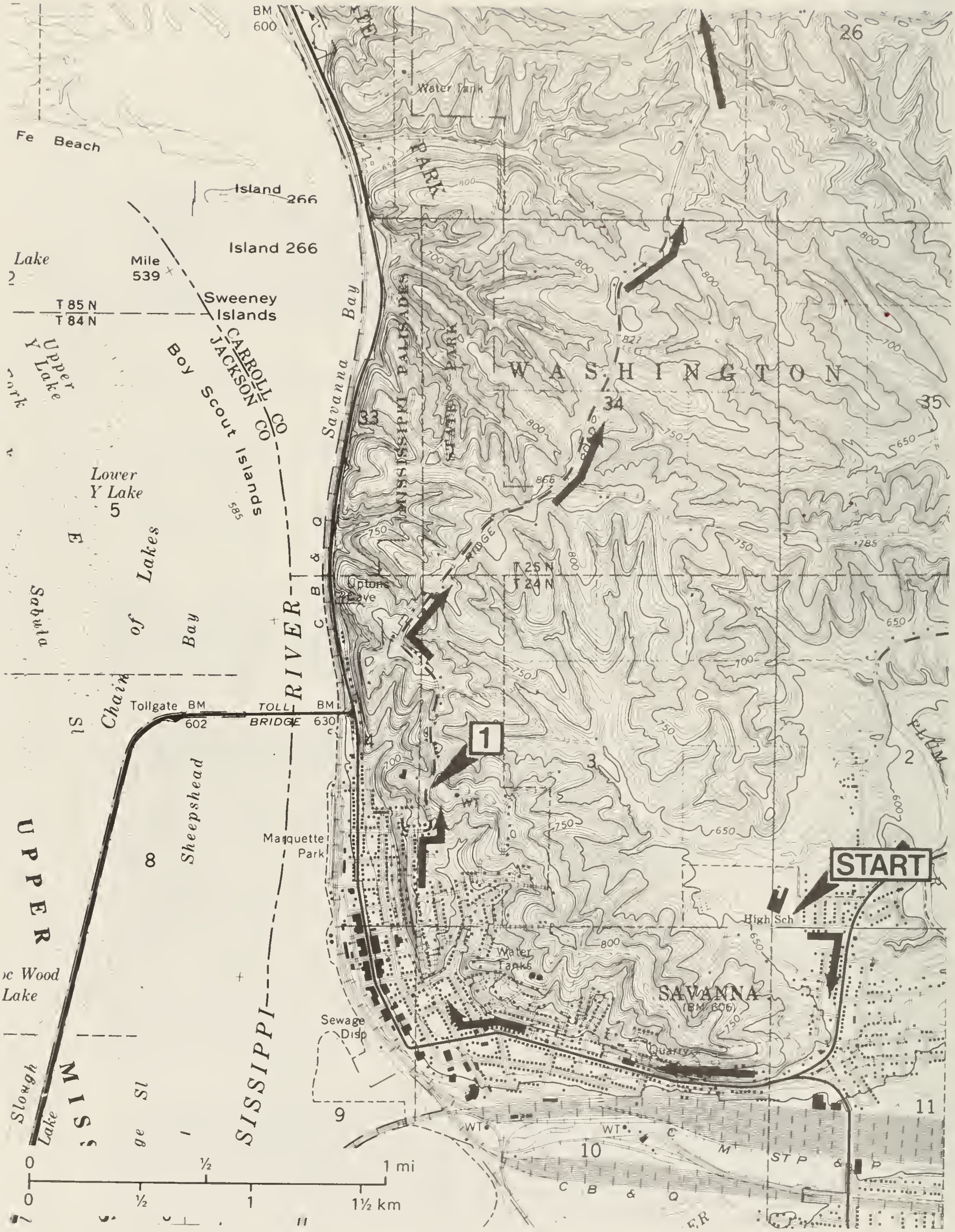
[1] The Illinois State Geological Survey (ISGS) conducts electrical earth resistivity surveys as part of a free service program to help locate industrial, public, and private groundwater supplies. Resistivity surveys are useful in prospecting for buried, water-bearing sand and gravel in glacial drift, and alluvium above the bedrock surface. By using general geologic data about a locality and information obtained by an electrical earth resistivity survey, geologists can predict the water-bearing potential of earth materials. Since 1932 the ISGS has made more than 2,000 resistivity surveys in the state, covering areas ranging from one acre to many square miles.

GUIDE TO THE ROUTE

Miles/ next point	Miles/ starting point	
0.0	0.0	Mileage figures begin three blocks west of Illinois (IL) Route 64 and US 52 at the intersection of Cragmoor Street and Longmoor Avenue at the southeast side of Savanna High School (SW SW SW SW sec. 2, T24N, R3E, 4th P.M., Carroll County, Savanna 7.5-minute Quadrangle [42090A2*]). HEAD EAST on Longmoor Avenue.
0.15	0.15	STOP: 1-way at Chicago Avenue. TURN RIGHT (south) on IL 64 and US 52.
0.35	0.5	CAUTION: you are approaching a highway junction under construction.
0.05+	0.55+	CAUTION: junction of IL 64 and US 52 with IL 84. BEAR RIGHT southwesterly.
0.9	1.45+	Prepare to turn right.
0.1+	1.55+	TURN RIGHT (northwesterly) on South Fourth Street at sign pointing toward hospital.
0.1+	1.7+	Ascend steep hill.
0.25+	2.0	Downtown Savanna and the Mississippi River can be viewed to the left (west). Toward the northwest is a good view of both sides of the Mississippi Valley.
0.15+	2.15+	STOP: 1-way. TURN RIGHT (east) uphill on Webster Street toward the hospital.
0.15+	2.35+	TURN LEFT (west) into the Savanna City Hospital parking lot (limited space available). PARK.

* The number in brackets following the topographic map name, [42090A2], is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first pair of numbers refers to the latitude of the southeast corner of the block and the next three numbers designate the longitude. The blocks are divided into 64 7.5-minute quadrangles; the letter refers to the east-west row from the bottom, and the last digit refers to the north-south column from the right.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MISSISSIPPI PALISADES STATE PARK
MISSISSIPPI RIVER
UPPER MISS
Savanna Bay
Island 266
Sweeney Islands
Boy Scout Islands
CARROLL CO
JACKSON CO
Mile 539
T 85 N
T 84 N
T 25 N
T 24 N
Lower Y Lake
Upper Y Lake
Sabula
Chain of Lakes
Bay
Sheepshead Sl
Tollgate BM 602
TOLL BRIDGE
BM 630
Marquette Park
Uptons Cave
Water Tank
Water Tanks
High Sch
Quarry
Sewage Disp
Fe Beach
0 ½ 1 mi
0 ½ 1 1½ km

STOP 1. View and discussion of the evidence for the Plum River Fault Zone in this vicinity (SW NW NW SW sec. 3, T24N, R3E, 4th P.M., Carroll County, Savanna 7.5-minute Quadrangle [42090A2]).

Worthen (1866) first recognized that structural deformation had occurred in this part of the state. Early investigators felt that an east-west-trending anticline and a syncline were the structural features present here. Willman and others (1967) first recognized that the structure in this part of Illinois was partly the result of faulting when they mapped a fault on the north side of Savanna that extended approximately 4 miles east of the Mississippi River.

Kolata and Buschbach (1976) found strong surface and subsurface evidence for the presence of faults with 100 to 400 feet of vertical displacement that extended from Leaf River, Illinois, westward across Ogle and Carroll Counties for about 60 miles to an area south of Maquoketa in Jackson County, Iowa. Everywhere along the faulted zone, which they called the Plum River Fault Zone, bedrock was found to be downthrown on the north side. They found the best field evidence for faulting in the bluffs and ravines in the unglaciated area from Savanna eastward to Mt. Carroll. A vertical displacement of 100 to 150 feet can be detected in bedrock strata exposed in the vicinity of the hospital.

On the east side of Ridge Road across from the parking lot, thin-bedded, argillaceous dolomite of the lowermost Alexandrian Series (Silurian) Mosalem Formation (fig. 4) is exposed in the roadcut. Some 600 to 700 feet west-northwest beyond the hospital at an elevation of about 800 feet mean sea level is an exposure of thick dolomite beds of the lower Niagaran Series (Silurian) Marcus Formation, which contain abundant *Pentamerus* fossils. Figures 7 and 8 show the location of the faults in this vicinity and the relationships of lower bedrock horizons that were used to make the map and cross section. We see that the Marcus Formation, which occurs stratigraphically more than 100 feet above the argillaceous lower Mosalem beds, is about 40 to 50 feet lower than the latter here. The Plum River Fault Zone lies beneath the blacktop parking lot.

The time of faulting is not known with certainty. Clearly, deformation occurred sometime after the Niagaran strata had formed. Since Kolata and Buschbach could find no evidence of faulting in the middle Illinoian (Pleistocene) glacial drift to the east in Ogle County, the Plum River Fault Zone must have formed sometime before the glaciation.

0.0	2.35+	Leave STOP 1. TURN LEFT (northerly) leaving the parking lot.
0.7	3.05+	Iowa upland is in the distance to the left; to the right are glimpses of the Silurian upland.
0.4-	3.45	T-road intersects from the right. CONTINUE AHEAD (northerly).
1.4	4.85	Offset cross road. CONTINUE AHEAD (northerly).
0.2+	5.05+	Transformer substation appears on the left.
0.6-	5.65	T-road intersects from the right. CONTINUE AHEAD (northerly).


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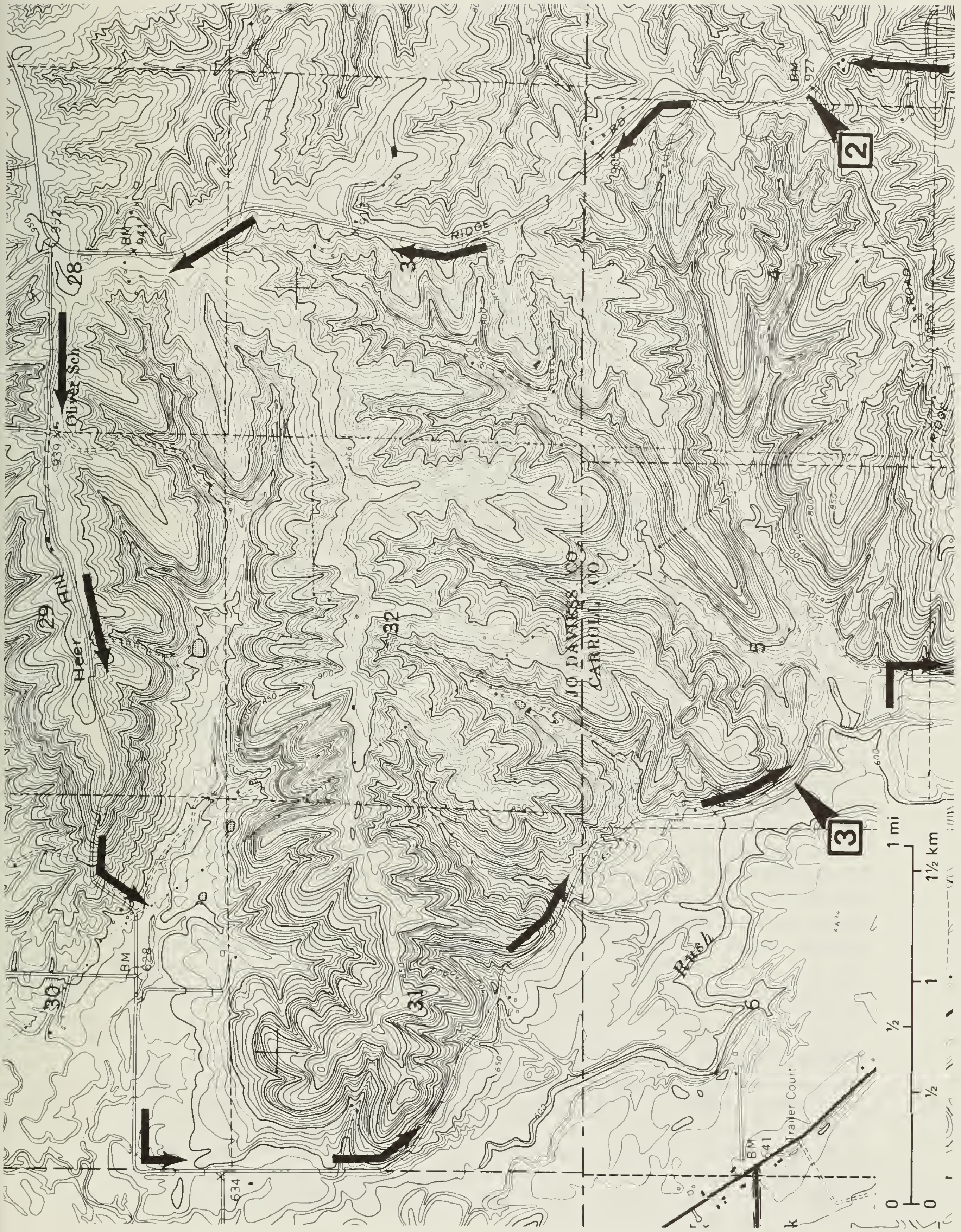
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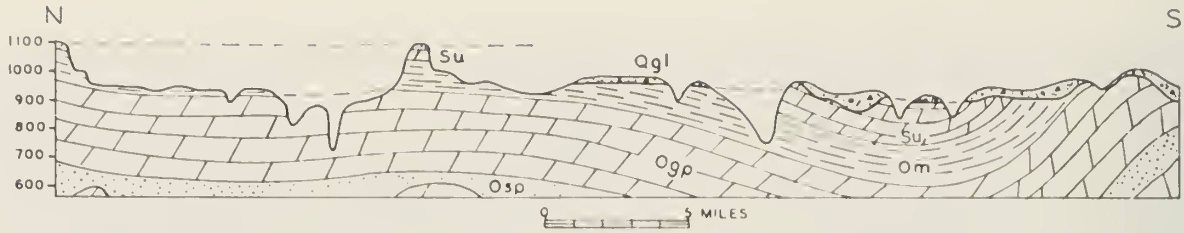


Figure 9 Cross section shows Dodgeville (upper) and Lancaster (lower) surfaces in northwestern Illinois from Apple River southeasterly to northwestern Carroll County: Qgl - glacial drift; Su - Silurian dolomite; Om - Maquoketa shale; Ogp - Galena-Platteville dolomite; Osp - St. Peter Sandstone. (From Horberg, 1950.)

1.85	7.5	T-road (Mill Hollow Road) intersects from the left. CONTINUE AHEAD (northerly).
0.65	8.15	At St. Peter Lutheran Cemetery, T-road intersects from the right on the curve. CONTINUE AHEAD (northerly).
0.75+	8.9+	T-road intersects from the right. CONTINUE AHEAD (northerly).
0.1+	9.0+	T-road (Sand Ridge Road) intersects from the left. CONTINUE AHEAD (northerly) and prepare to stop.
0.05	9.05+	CAUTION: park along the right shoulder of the road.

STOP 2. Discussion of upland surfaces in the Savanna area (east side of Ridge Road, NW SW NW SW sec. 3, T25N, T3E, 4th P.M., Carroll County, Blackhawk 7.5-minute Quadrangle [42090B2]).

The topography of the field trip area has a long history of development. Since the last Paleozoic sea withdrew from the Midcontinent region at the end of the Pennsylvanian Period about 286 million years ago, or possibly as late as the end of the Permian Period nearly 245 million years ago, the Upper Mississippi Valley region has remained above sea level. During this long interval of time, many hundreds of feet of Paleozoic strata have been eroded away. During the Pliocene Epoch between 5.3 and 1.6 million years ago near the end of the Tertiary Period, the region was reduced to an erosional plain known as the Dodgeville Peneplain. Worn away by stream erosion and mass wasting to low, nearly featureless land, the peneplain gradually sloped downward to the sea. Such an erosional surface, which required a very long time to develop, was characterized by sluggish streams flowing in broad valleys. Bedrock structures such as anticlines had no influence on the topography because they were uniformly beveled.

After the Dodgeville Peneplain formed, the region was uplifted and a smaller erosional plain called the Lancaster Peneplain developed on the bedrock at a lower level. In the Driftless Area of Wisconsin, the Dodgeville surface is well preserved. In Jo Daviess County, Illinois, remnants of the Dodgeville Peneplain are preserved as isolated, flat-topped ridges and knobs of Silurian dolomite (fig. 9). When the tops of these Silurian flats are joined by an imaginary plane, a surface forms that represents the former peneplain sloping gently southwestward from an elevation of about 1150 to 1000 feet mean sea level.

The Lancaster Peneplain, which occurs about 200 feet lower than the Dodgeville Peneplain, is extensively preserved on the bedrock surface of northern Illinois. It is well developed in the Driftless Area. East of the Driftless Area, it is a gently undulating surface covered by the glacial deposits. It closely coincides with the top of the Galena dolomite and slopes southwestward from an elevation of about 950 to 800 feet mean sea level. The Savanna area lies at the southern edge of the Lancaster Peneplain. The peneplain bevels the bedrock structure along the Plum River Fault Zone and associated structures, so that the surface occurs on the Galena dolomite, the Maquoketa shale, and the Silurian formations (fig. 9). The Lancaster surface is evident by the evenness of the horizon toward the east, north, and west as seen from this vantage point. This level appearance of the skyline is caused by the merging of nearly common summit levels.

The present topography of the Savanna area was produced by streams dissecting the Lancaster Peneplain during the Pleistocene glaciations and modification of the dissected surface by glacial deposits. The Driftless Area is more rugged than adjacent areas because it was not glaciated.

0.0	9.05+	Leave STOP 2. CONTINUE AHEAD (northerly) on Ridge Scenic Road. Ahead you will have several opportunities to view the upland surface on both sides of the road.
2.2	11.25+	Prepare to turn left from Ridge Scenic/Derinda Road just ahead.
0.1	11.35+	TURN LEFT (west) on Heer Hill Road. There are several good views of the uplands as we travel through this area.
0.5+	11.85+	T-road (Curtis Hill Road) intersects from the right. CONTINUE AHEAD (westerly).
1.1	12.95+	CAUTION: descend steep hill. Road narrows.
0.6	13.55+	T-road intersects from the right. CONTINUE AHEAD (westerly) and note remnants of modern stream terraces on both sides of the road.
0.2	13.75+	The surface to left has been scoured by old channels that developed when the tributary valley was draining the melting glaciers toward the Mississippi River.
0.3+	14.05+	TURN LEFT (south).
0.25	14.3+	T-road intersects from the right. CONTINUE AHEAD (south).
0.7-	15.0	To the right is an excellent view across the valley of Rush Creek as it opens into the Mississippi Valley. As we travel southward, you will have a number of excellent views of geomorphic features along Rush Creek. Note especially the terraces on both sides of the creek.
1.5	16.5	CAUTION: PARK along the road shoulder. DO NOT BLOCK the road.

STOP 3. Discussion of geomorphic features along Rush Creek (N/2 SE NW SW sec. 5, T25N, R3E, 4th P.M., Carroll County, Blackhawk 7.5-minute Quadrangle [42090B2]).

In looking around this area, you will notice that we are stopped on the most pronounced terrace in this vicinity. Its surface elevation is about 635 feet mean sea level. During the glacial period, the Mississippi River was blocked by ice several times, and large lakes formed upstream from the blockages. Sand and gravel was deposited close to the main stem of the Mississippi, but fine-grained lake silts settled in the quiet backwaters formed by the inlets of tributaries.

As the topography of this area shows (see map on p. 15), there were probably several episodes of silt deposition. Each was followed by stream dissection that left remnants of the old flat lake beds as terraces. The stream course was first established as it meandered from one low sag to another across the draining lake bottom. Periodic downcutting left the older, higher meander scars perched above the present level of Rush Creek. After this terrace level that we are standing on was eroded, silts were deposited along Rush Creek at least one other time. Many scour channels and meander loop remnants lie some 20 to 25 feet below us. Modern drainage has cut through a number of these features. The lower course of the modern Rush Creek is a good example of a meandering stream (fig. 10).

The relief of the bedrock surface in the Savanna area closely relates to the establishment of the Mississippi Valley during early Pre-Illinoian glaciation. Maximum surface relief probably developed later during the same period of glaciation when the valley was eroded to its maximum depth by glacial meltwater. After that the valley was alternately aggraded by outwash and re-excavated. Deposition of thick valley train sands and gravels in the Mississippi Valley during the late Wisconsinan Woodfordian and Valderan glaciations aggraded the valley to a level approximately

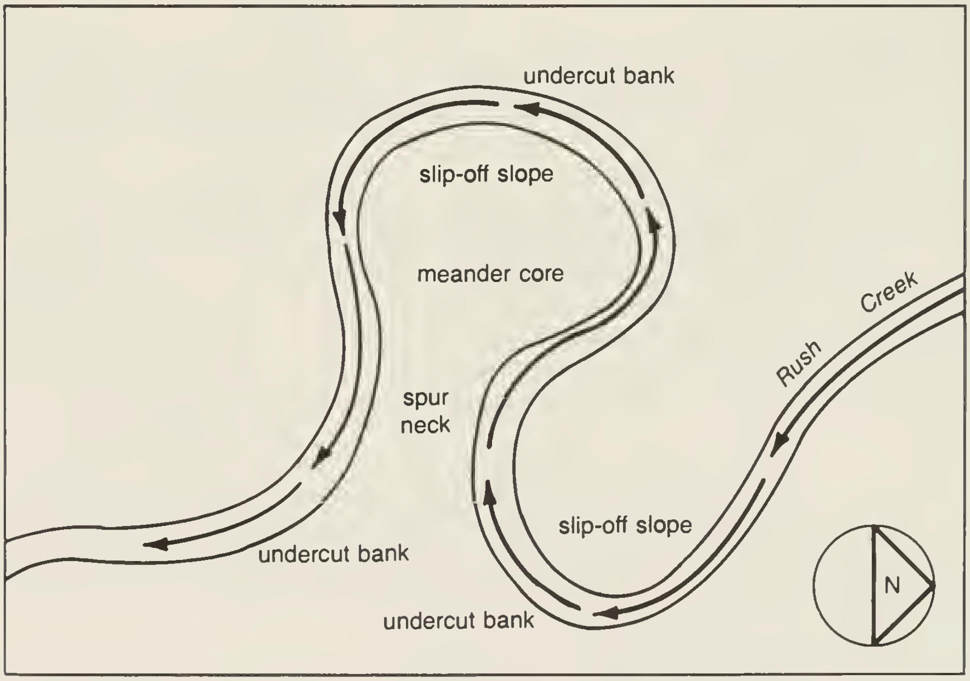
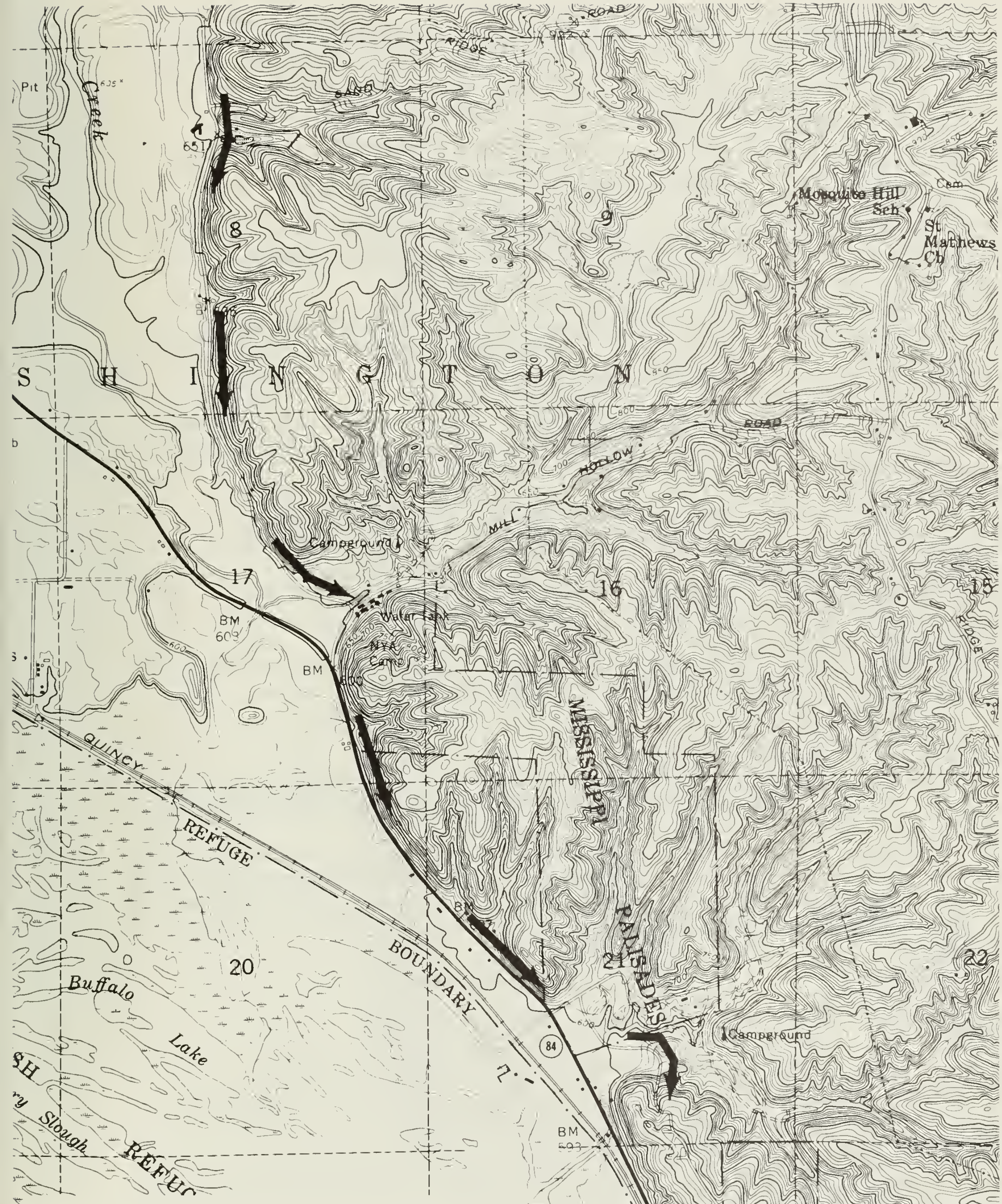


Figure 10 Diagram of meanders along Rush Creek. Arrows show the axis of current flow.


ROAD
RIDGE
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MILL
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16
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RIDGE
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NYA
Camp
BM
603
BM
600
QUINCY
REFUGE
BOUNDARY
MISSISSIPPI
PALISADES
BM
20
21
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Lake
Slough
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Campground
BM
593
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1 mi
0
½
1
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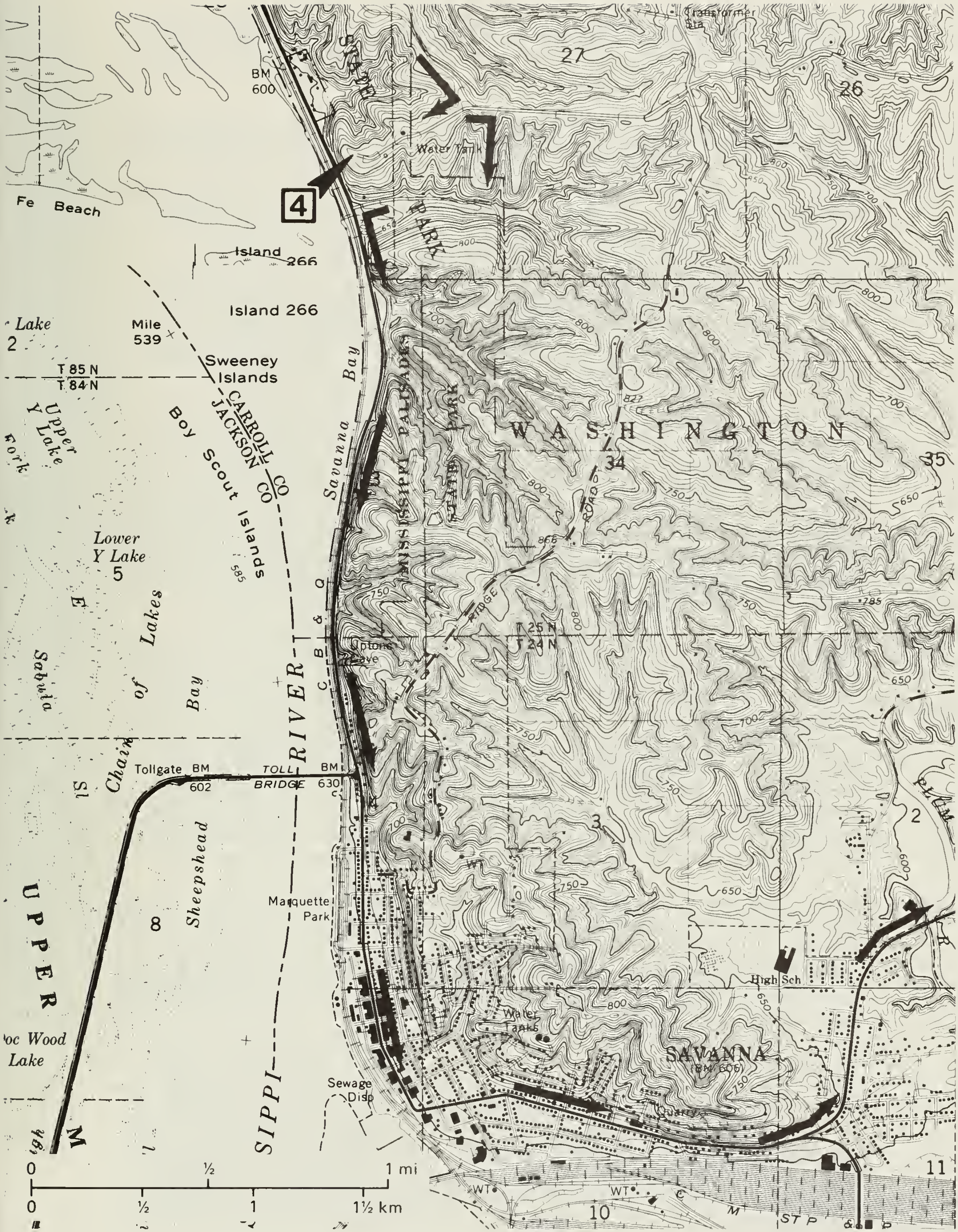
30 feet above its present floodplain, as shown by the large terrace remnants we can see here at Stop 3. Tributary valleys were also deeply alluviated. During Holocene time, since the last glacier melted away, the Mississippi River and its tributaries have been deepening their valleys by eroding Wisconsinan alluvial deposits. Nearly 100 feet of alluvial fill lies below the present Mississippi channel in this area.

0.0	16.5	Leave STOP 3 and CONTINUE AHEAD (southerly).
0.7	17.2	T-road (Sand Ridge Road) intersects from the left. A small sand pit is located just around the corner on the north side of the road. CONTINUE AHEAD (southerly).
0.1+	17.3+	*Equisetum*, a scouring rush whose ancestors were tree-size plants during the Pennsylvanian Period, occurs along the right shoulder of the road.
1.4+	18.7	CAUTION: cross culvert--the side of which is NOT well marked. T-road intersects just beyond culvert. TURN RIGHT (southwest) on Mill Hollow Road.
0.15+	18.85+	STOP: 1-way. T-road intersects with IL 84. TURN LEFT (southerly) with CAUTION onto IL 84: FAST TRAFFIC.
0.2	19.05+	Cliff faces of Silurian dolomite to the left are part of the Mississippi Palisades State Park.
0.65-	19.7	Mississippi Palisades State Park offices are located to the left. CONTINUE AHEAD (southeasterly).
0.15	19.85	Prepare to turn left.
0.1+	19.95+	TURN LEFT (northeast) at entrance to Mississippi Palisades State Park. USE EXTREME CAUTION in the park area.

Illinois acquired the property for Mississippi Palisades State Park in 1929. According to a park brochure of 1968, "the sheer cliffs, with fern-clad slopes, weather-worn crags and densely wooded areas are reminiscent of the famed Palisades of the Hudson River, for which the park is named." The park covers more than 1,700 acres.

0.05+	20.05+	T-intersection: TURN RIGHT (southerly).
0.3	20.35+	CAUTION: ascend steep hill.
0.1	20.45+	Wisconsinan Peoria Loess is exposed in road cuts.
0.15-	20.6	Entrance to Louis Point is located on the right. CONTINUE AHEAD (southeasterly).
0.8+	21.4+	T-road intersection: TURN RIGHT (southwesterly) toward Lookout Point.
0.35	21.75+	PARK in horseshoe parking area or along the road.



4
Fe Beach
Island 266
Mile 539
Sweeney Islands
T 85 N
T 84 N
CARROLL CO
JACKSON CO
Boy Scout Islands
Upper Y Lake
Lower Y Lake
Chain of Lakes
Sabula
Savanna Bay
Bay
Sheepshead
Tollgate
TOLL BRIDGE
BM 602
BM 630
RIVER
SIPPI
UPPER
Marquette Park
Sewage Disp
STATE PARK
MISSISSIPPI PALISADES STATE PARK
WASHINGTON
Water Tank
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Upton Cave
T 25 N
T 24 N
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STOP 4. View of the Mississippi Valley from the observation platform below the parking area and discussion of its history (NW SE NE SE sec. 28, T25N, R3E, 4th P.M., Carroll County, Blackhawk 7.5-minute Quadrangle [42090B2]).

The most imposing topographic feature in the field trip area is the Mississippi Valley, especially where it has incised the resistant Silurian dolomite to form the Mississippi Palisades. High on the bluffs east of the Mississippi Valley near East Dubuque, Survey geologists discovered early Pre-Illinoian outwash--evidence that the river was probably not entrenched in its present valley in the Savanna area until after that early glaciation. These Pre-Illinoian outwash deposits consist of coarse gravel overlying lake sediments in small, shallow channels eroded into the surface of the dolomite bedrock 200 feet above the floodplain. The position of the valley from the vicinity of St. Paul, Minnesota, southward along the west side of the Driftless Area closely follows the margin of the early Pre-Illinoian glacial deposits. Apparently, this early glaciation established the position of the valley, which developed from an ice marginal stream during the maximum advance of the ice sheet.

Just south of Galena in Jo Daviess County, the Mississippi Valley cuts through a prominent north-facing escarpment of Silurian dolomite (fig. 3). The front of the escarpment stands about 200 feet above the level of the Lancaster Peneplain. This escarpment, or cuesta, is the erosional edge of the Silurian dolomite formations that dip gently southwestward off the Wisconsin Arch (fig. 5). At this spot, the Mississippi Valley is slightly more than 2 miles wide. A short distance extending north and south on either side of the faulted zone, the Mississippi River has eroded its valley into the relatively soft Maquoketa shale below the resistant Silurian dolomite. The valley is as much as 13 miles wide where the river has eroded the softer bedrock strata.

At the beginning of the Ice Age, the Upper Mississippi Valley region of northwestern Illinois, northeastern Iowa, and southwestern Wisconsin was a plain of low relief at the level of the present uplands (Lancaster Peneplain). The Silurian escarpment was a continuous divide extending across northwestern Jo Daviess County into Iowa. Streams flowed northward and southward from the divide in broad, shallow valleys, high above the present drainage. No evidence shows that a major south-flowing stream existed in the Savanna area, but several of the major tributaries to the present Mississippi may follow courses established at that time. Farther south, an ancestral river called the Ancient Iowa River had its headwaters in east-central Iowa and followed the present course of the Mississippi Valley below Muscatine, Iowa.

With the advance of the early Pre-Illinoian glacier, the first of the Pleistocene glaciers to invade the Upper Mississippi Valley region, northward drainage was blocked and a meltwater lake formed in front of the Silurian Escarpment north of Galena. The meltwater eventually spilled over the divide at Galena and eroded a channel through the escarpment. The water then flowed southward and eroded a valley along the margin of the early Pre-Illinoian glacier.

By the end of this early glaciation, the Mississippi River had established its valley along the west side of the Driftless Area southward as far as Fulton in Whiteside County. From there, it followed a southeastward course to the present big bend of the Illinois River Valley in Bureau County (note small maps in appendix). The river then followed the present course of the Illinois Valley southward to its confluence with the Ancient Iowa River at Grafton, Calhoun County. Except for a temporary diversion by the Illinoian glacier, the Ancient Mississippi River followed this course from Fulton to the big bend and southward along the Illinois River Valley until the

Wisconsinan glaciation. During the Woodfordian advance, the river was permanently diverted westward to occupy the valley of the Ancient Iowa River along the west side of what is now Illinois, a course it still follows. Its former valley from Fulton to the big bend, known as Princeton Valley, was buried by Wisconsinan drift.

Willman (1973) described the following geologic section a few feet north of this observation platform. It is called the Palisades Park Main Entrance Section:

Silurian System
- Racine and Marcus Formations
  - •Dolomite, massive; mostly inaccessible for detailed study; *Pentamerus* abundant at base; 82 feet.
- Sweeney Formation
  - •Dolomite, gray, fine-grained; massive-appearing but has weak, thin, wavy bedding with green clay partings; contains many silicified corals; 45 feet.
- Blanding Formation
  - •Dolomite, light brownish gray, fine- to medium-grained, slightly argillaceous, dense to finely vesicular; in 2-4 inch beds; contains many 2-6 inch layers, lenses, and nodules of white chert; corals common; 28 feet.
  - •Dolomite, as above but thicker bedded and contains chert only in scattered nodules in upper 2 feet and in band 3 feet below top; 6 feet.
- Mosalem Formation
  - Strongly pitted, iron-stained corrosion surface.
  - •Dolomite, argillaceous, brown, mottled greenish gray; massive except for a few tight wavy bedding planes and weak laminations; upper 1 foot relatively pure and vuggy, with fucoidal mottling; lower 3 inches is fossiliferous, vuggy, calcarenitic dolomite; strong bedding reentrant at base; 7 feet 3 inches.
  - •Dolomite, brown, fine-grained; massive ledge but strongly laminated; upper 1 foot irregularly vuggy; upper 3 inches contains many casts of fossils; 0- to 1-inch lens of white chert at base; locally thins sharply to 6 inches; 2 feet.
  - •Dolomite, argillaceous, light brown and green, laminated; thins out at margin of channel cut into underlying shale; 8 inches.

Ordovician System
- Maquoketa Group
  - Brainard Shale
    - •Dolomite, very argillaceous, soft, light greenish gray; 1 foot 8 inches to 3 feet.
    - •Shale, dolomitic, greenish gray; 2 inches.
    - •Dolomite, very argillaceous as above; base concealed; 3 inches.

Karst topography appears in this area. Typical features include several deep solution pits or sinkholes, such as the one along the south edge of the parking area. In addition, some small caves have formed from solution along joints and cracks in the dolomite. The sinkholes act as large funnels, collecting rainwater and channeling it into underlying joints and cracks.

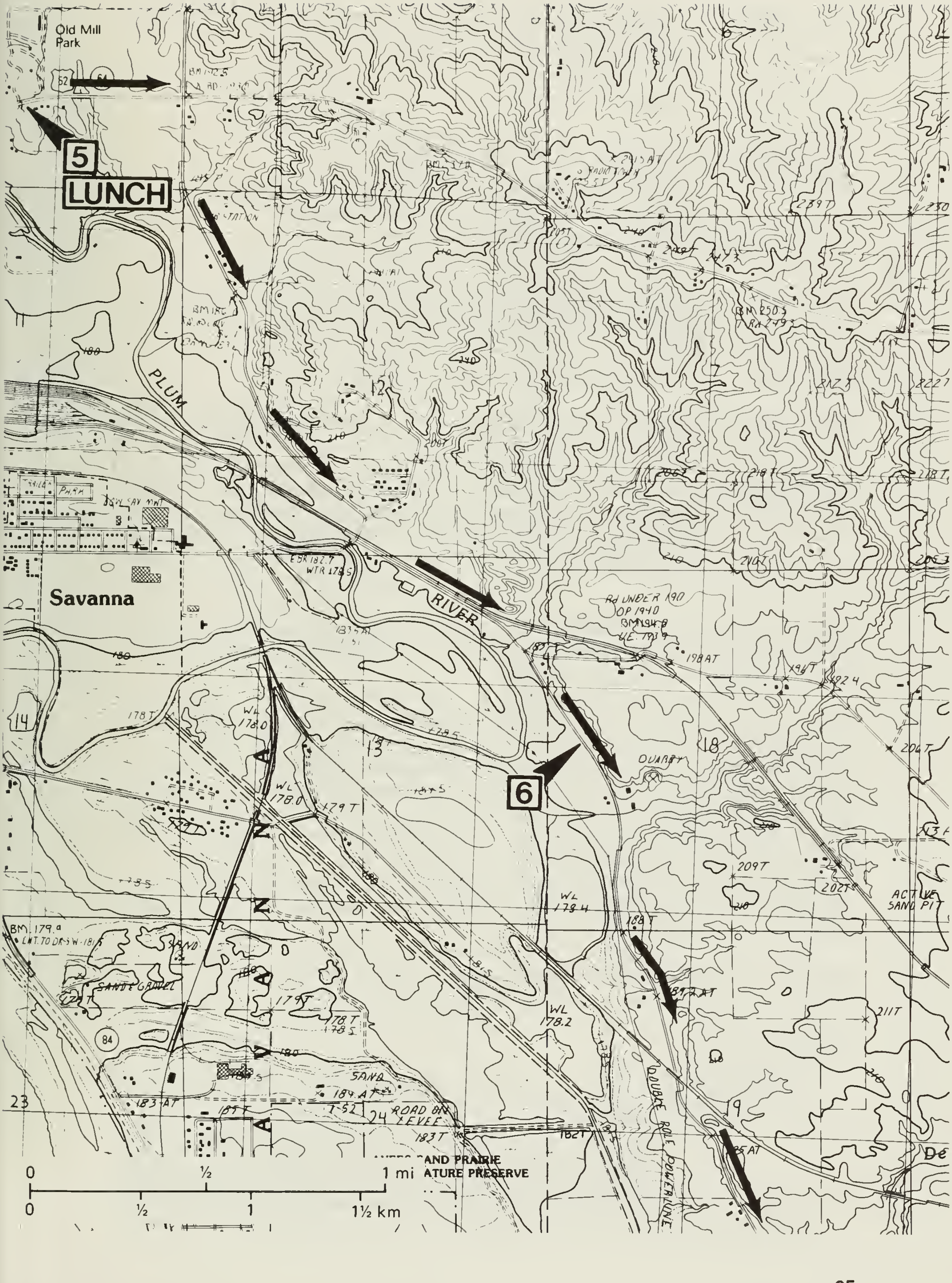
Four conditions contribute to the development of karst topography. First, soluble rock, flat or nearly so, lies at or near the surface. Second--and most important--the limestone or dolomite is dense, highly jointed, and generally thin-bedded. If the stone were porous, rainwater would be absorbed and move through the whole body of the rock rather than concentrate along joints and bedding planes. Third, major valleys are entrenched below the uplands and act as outlets toward which the groundwater

moves in the subsurface. Fourth, rainfall is ample. (The name "karst topography" comes from the Karst region of the Dinaric Alps in Yugoslavia, where such features are common.)

When the solution process reaches extreme development, isolated, steep-sided pinnacles of bedrock are all that remain of the once continuous jointed layer of limestone or dolomite. This kind of topography is well developed in the Guangxi Province of southern China; its unusual and hauntingly beautiful shapes are often depicted in Chinese art.

0.0	21.75+	Leave STOP 4 and retrace your route.
0.35	22.1+	STOP: 1-way at T-road intersection on the curve. TURN RIGHT (southerly) and prepare to descend a steep hill with caution.
0.75+	22.9-	PARK ENTRANCE. STOP: 1-way. Note the spring on the right side at the entrance gate. TURN LEFT (south) with CAUTION onto IL 84: FAST TRAFFIC.
0.55+	23.45	To the left and high up on the bluff is a small cave opening.
0.45	23.9	Stone steps to the left lead up to the Bob Upton Cave opening about 25 feet above the highway. Do NOT park along the highway here. Parking is available either at mileage 23.8+ or ahead at 24.0, and then you can carefully walk to the cave.
0.5+	24.4+	CAUTION: Savanna City Limits.
0.1	24.5+	Savanna-Sabula Bridge entrance is located to the right and junction with IL 64 and US 52. CONTINUE AHEAD (south) to the business area.
0.45+	24.95+	CAUTION: enter the Savanna business district. CONTINUE AHEAD (south and then east).
0.65+	25.65-	Retrace earlier part of itinerary.
0.85+	26.5+	CAUTION: approach junction of IL 64 and 84 and US 52.
0.1	26.6+	BEAR LEFT (northeasterly) on IL 64 and US 52.
0.7+	27.35	Cross Plum River and prepare to turn left.
0.1+	27.45+	TURN LEFT at entrance to Old Mill Park. Follow drive around to the picnic areas.
		NOTE: pick up mileage at the entrance when leaving.

STOP 5. LUNCH (NW NW SW SE sec. 2, T24N, R3E, 4th P.M., Carroll County, Wacker 7.5-minute Quadrangle [42090A1]).



Old Mill Park
5
LUNCH
6
Savanna
PLUM
RIVER
QUARRY
SAVANNA
SAND PRAIRIE
NATURE PRESERVE
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1 mi
0
½
1
1½ km

0.0	27.45+	Leave STOP 5. CAUTION: TURN LEFT (east) on IL 64 and US 52: FAST TRAFFIC.
0.35	27.8+	Prepare to turn right.
0.1+	27.95-	TURN RIGHT (south) at cross road.
0.15+	28.1	Here the main terrace remnants appear to be about 15 feet lower than were those along Rush Creek at STOP 3.
0.8	28.9	Ordovician Galena dolomite is exposed in the roadcut on the left.
0.45	29.35	CAUTION: one unguarded railroad track (Soo Line Railroad). Just beyond it is a Y-intersection. BEAR LEFT (east).
0.55+	29.9+	Y-intersection: BEAR RIGHT (south).
0.25	30.15+	CAUTION: you are entering a quarry area where heavy equipment crosses the roadway.
0.05+	30.2+	CAUTION: PARK along the right shoulder of the road--out of the way of quarry vehicles. The office of Oregon Stone, Inc. is on the east side of the road. YOU MUST HAVE PERMISSION to enter this property.

STOP 6. Examination of Galena Group dolomite of Ordovician age and overlying Pleistocene sand (NW NE NW SW sec. 18, T24N, R4E, 4th P.M., Carroll County, Wacker 7.5-minute Quadrangle [42090A1]).

Overlying the Ordovician bedrock here is an excellent exposure of Pleistocene sand that appears to be atypical in its occurrence. The lower 10 feet or so appears to have been waterlaid, so it is assigned to the Wisconsinan Henry Formation. The upper 20 to 25 feet is windlaid material that is assigned to the Woodfordian Parkland Sand. Behind the equipment area, the total thickness of sand is about 30 to 35 feet. A few feet of the topmost material were removed before quarrying so that soil materials would not become mixed with the underlying sand. The large exposure shows evidence of prehistoric slumping, probably not long after the sand was deposited. Excellent crossbedding and small-scale faults resulting from the slumping are well shown across the face.

The bedrock on the northeast part of the quarry face was described by J.H. Goodwin and D.L. Reinertsen on April 17, I989:

Ordovician System
- Champlainian Series
  - Trentonian Stage
    - Galena Group
      - Dubuque Formation
        - •Dolomite, yellowish tan, appears to be thinner bedded (in beds 0.5 foot or less) than underlying strata; it is more highly fractured and jointed with many iron-stained mud fillings; small sinkholes appear in the upper part; the stone becomes more sandy upwards, probably the result of

weathering; it also is soft and friable in the upper part; the rock has almost a brecciated appearance in part: 10 feet+.
•Dolomite, yellowish tan, sandy becoming more sandy toward top; top 0.15 foot has abundant reddish iron-staining: 0.9 foot.

Kimmswick Subgroup

Wise Lake Formation

Stewartville Member

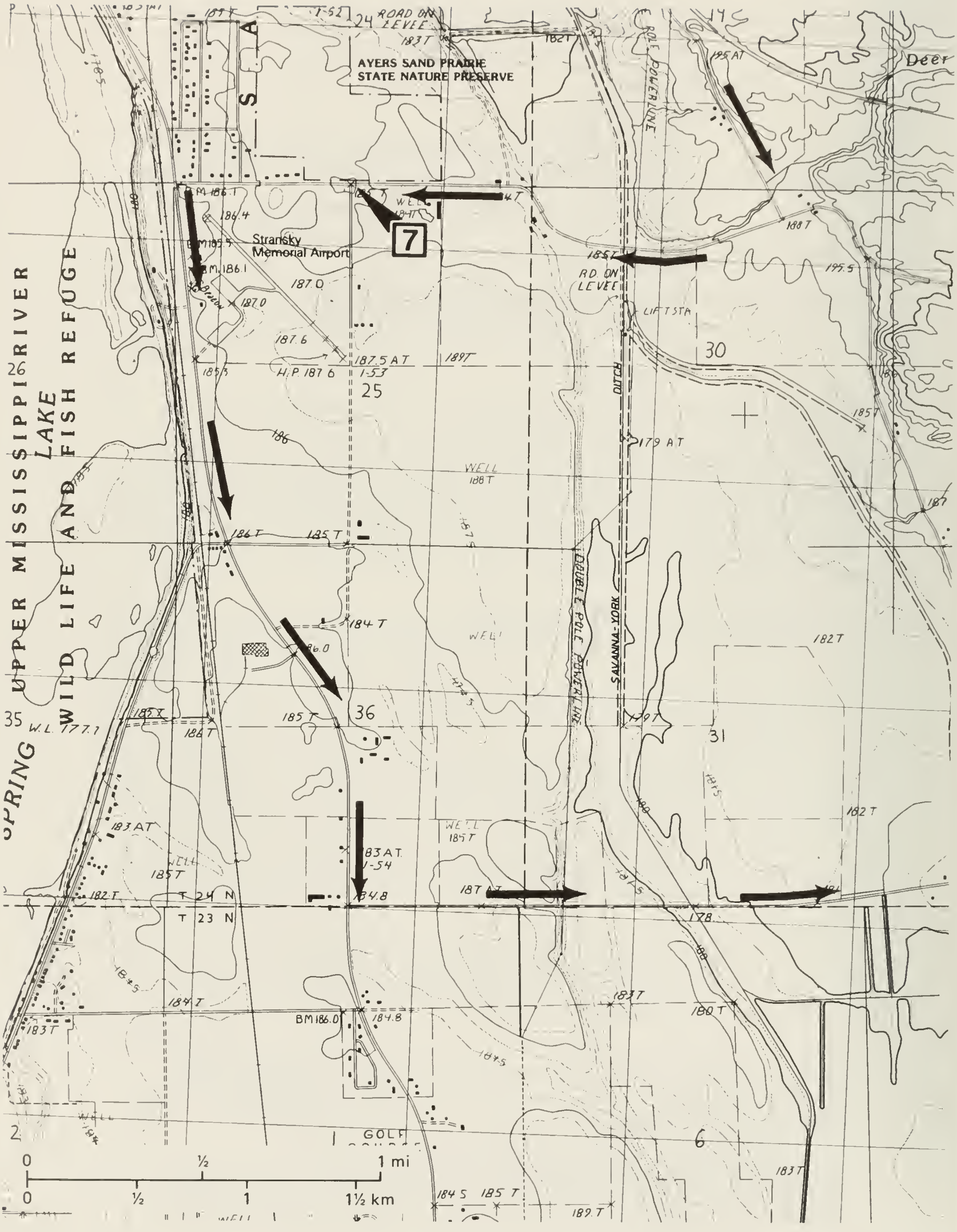
•Dolomite, light brown mottled with light grayish brown; beds range from 0.8 to 2.5 feet thick; contains small vugs up to 0.5 inch in diameter: 8.2 feet.
•Dolomite, as above but with reddish brown silty interbeds; 1.8 feet.
•Siltstone, light tan to yellowish tan with thin reddish brown interbeds; dolomitic; fine-grained; may have been a hard surface at one time as deduced from the staining: 0.1 to 0.2 foot.
•Dolomite, light brown mottled with light brownish gray; somewhat sandy in part; beds range from 0.8 to 2.5 feet thick: 9.5 feet+.
•Total thickness exposed, 31.4 feet; base under water. The south end of the pit was measured with a steel tape and a rock from above; 47 feet to water level.

The Dubuque Formation is the shaly dolomite at the top of the Galena Group. In Illinois, it is known only from the northwestern part of the state where it is 40 to 45 feet thick. It is truncated southward near Galesburg by overlying Maquoketa Group strata. The underlying Stewartville Member of the Wise Lake Formation is 30 to 35 feet thick in northern Illinois. This member is largely thick-bedded, pure dolomite, the lower part of which contains the Upper *Receptaculites* Zone; the upper part is thinner bedded as it grades into the overlying Dubuque Formation. The upper, thinner beds have been exposed in the quarry.

0.0	30.2+	Leave STOP 6. CONTINUE AHEAD (south).
1.0	31.2+	CAUTION: Burlington Northern (BN) Railroad underpass. Clearance is 11 feet 4 inches.
0.7	31.9+	Cross concrete bridge. To the left is a small waterfall over an exposure of Galena Dolomite.
0.05+	31.95+	CAUTION: unguarded T-road intersection. TURN RIGHT (west).
0.45	32.4+	Cross drainage ditch. Note the even, flat surface of the terrace just ahead.
0.5-	32.95	We are crossing an area of low sand dunes.
0.35-	33.3-	CAUTION: PARK along road shoulder. BEWARE of fast traffic. Do NOT cross the fence.

STOP 7. Discussion of sand dunes in northwestern Illinois. Ayers Sand Prairie Nature Preserve (SE cor. SW sec. 24, T24N, R3E, 4th P.M., Carroll County, Wacker 7.5-minute Quadrangle [42090A1]).

Ayers Sand Prairie Nature Preserve was acquired by the Illinois Nature Preserve Commission; it is administered and protected by the Illinois State Department of Conservation. Formally dedicated as a sanctuary for native vegetation and wildlife,


AYERS SAND PRAIRIE
STATE NATURE PRESERVE
Stransky
Memorial Airport
7
UPPER MISSISSIPPI RIVER
WILD LIFE AND FISH REFUGE
SPRING LAKE
ROAD ON LEVEE
RD. ON LEVEE
LIFT STA
DITCH
DOUBLE POLE POWER LINE
SAVANNA-YORK
POLE POWERLINE
Deer
GOLF
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this area is maintained in its natural condition so that present and future generations can see the Illinois landscape as it appeared to the pioneers.

Glacial meltwater spilling through the narrow, resistant Niagaran dolomite valley at Savanna easily eroded the softer shale and thin-bedded dolomite of the Maquoketa south of Savanna. Later, sediment-laden meltwater streams coursing through the narrow valley lost their ability to transport the huge volumes of sediment when they spread out across the wider valley. Valley trains formed along the main channels of the river. During the winter months when meltwater volumes drastically declined, the upper parts and surfaces of the valley trains were exposed to the drying action of the strong winds from the northwest. As noted previously, finer materials were winnowed from the coarse deposits and carried eastward by the prevailing winds. The coarser windblown material, such as sand, was deposited first, close to the streams. Increasingly finer materials were deposited farther eastward.

Here, sand lies on top of a terrace. The topography is characterized by a random arrangement of small hills or mounds, elongate ridges, and closed depressions. Wind piles up dunes wherever there is a ready source of sand and occasional strong winds. Although this dune area is not large, dune tracts similar to this one are fairly common on the valley flats adjacent to pronounced valley bluffs.

Transverse dunes are subparallel ridges that form at right angles to the effective wind direction; the downwind slopes are steeper than upwind slopes. The ridges of U-shaped dunes are convex downwind with the steepest slopes facing downwind. They form in both semi-arid and moist climates, and frequently are covered with vegetation even while they are forming. The dunes here do not have well-defined shapes, but appear to be mainly of the transverse variety. They are still active dunes, even though partly vegetated. Based on the orientation of their long dimension (NW-SE), they appear to be migrating to the northeast, indicating that the strongest prevailing winds are from the southwest.

0.0	33.3-	Leave STOP 7 and CONTINUE AHEAD (west). Note the distribution and configuration of the dunes as we proceed.
0.45+	33.75+	STOP: 1-way. TURN LEFT (south) on IL 84.
2.05	35.8+	Prepare to turn left.
0.1	35.9+	TURN LEFT at T-road intersection. Note that a number of center-pivot irrigation systems are being used in this area.
0.55+	36.5	You are descending from the terrace.
0.35+	36.85+	Cross drainage ditch.
0.75+	37.65+	Cross drainage ditch.
0.05+	37.7+	TURN RIGHT (south) at T-road intersection.
0.75+	38.5+	CAUTION: concrete culvert--sides are NOT well marked.
0.2	38.7+	Ditch on the left roadside has been cleaned out, exposing the greenish to olive-gray Maquoketa shale of Ordovician age.

0.35+	39.05+	TURN LEFT (easterly) at Y-intersection and ascend hill.
0.7+	39.8+	TURN RIGHT (south) at T-road intersection.
0.1+	39.95	PARK along road shoulder. Different parts of the section are exposed for about 0.1 mile downhill (east).

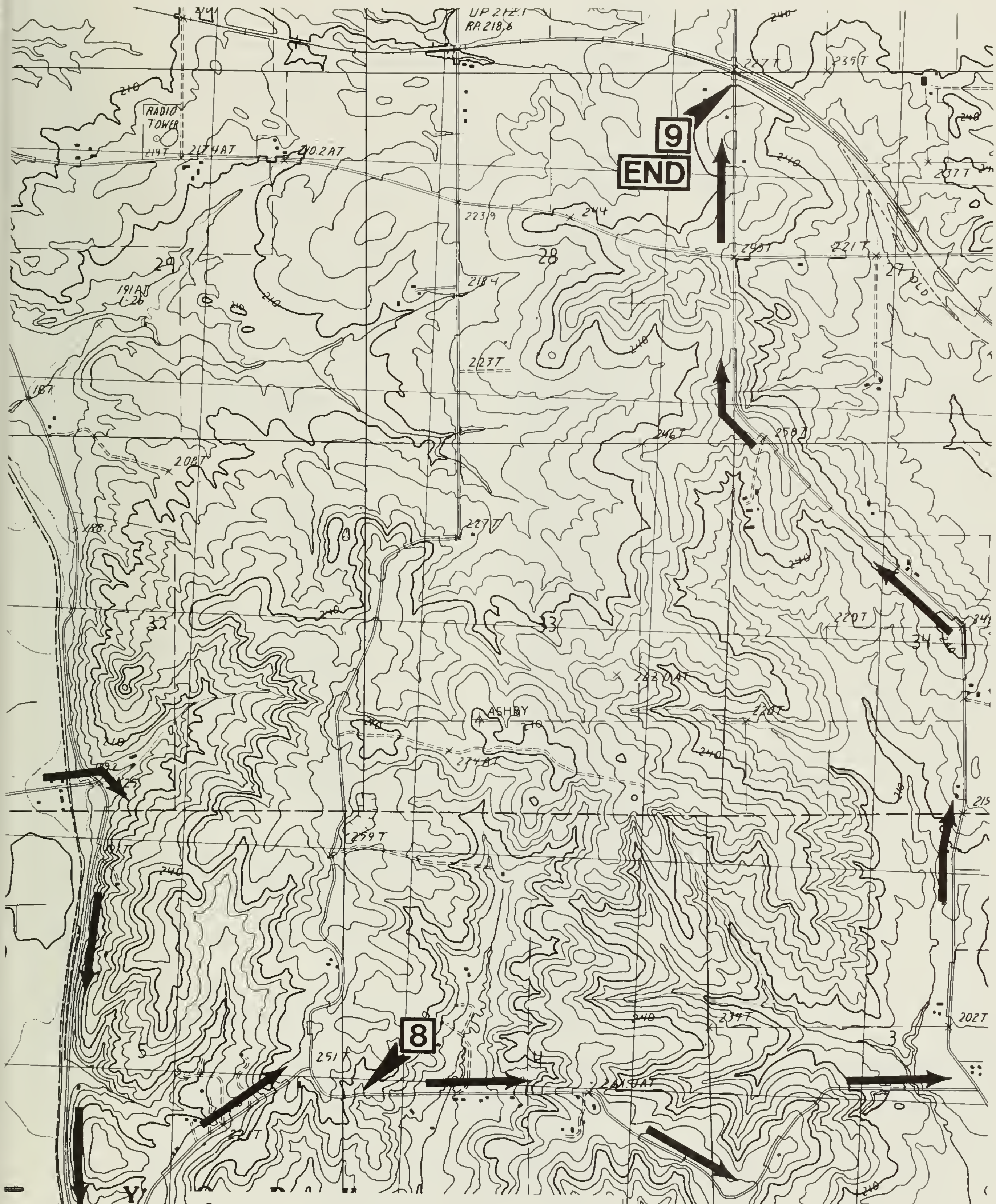
STOP 8. Discussion of upland sand dunes and the Illinoian glacial margin (S/2 SW SW NW sec. 4, T23N, R4E, 4th P.M, Carroll County, Wacker 7.5-minute Quadrangle [42090A1]).

An unusual display of Pleistocene Woodfordian sand and silt and Silurian bedrock is exposed in these roadcuts, for a distance of about 0.1 mile. Near the top of the hill at the smaller, upper roadcut, Woodfordian Peoria Loess maintains a vertical cutface and contains some thin, fine-grained sand zones that show salt efflorescence at the surface. Mottling and a darker coloration on the face is evidence of soil development at a time during which loess was accumulating. Apparently, accumulation slowed to the point that a minor soil was able to partly develop, after which loess continued to accumulate. Similar minor soils also occur in the Peoria Loess farther south in Illinois. Here, the loess is at least 10 feet thick with the modern soil developed in the top 18 inches or so. The loess appears to lap up onto the sand in the large roadcut just to the east. Relationships are not clear because the two roadcuts are separated by a deep, narrow valley.

The large roadcut exposes a crossbedded dune of Woodfordian Parkland Sand that is about 18 feet thick on the north side of the road. Capping the exposure is about 2 feet of Peoria Loess in which the modern soil has developed. Considerable slumping of the exposure has taken place over 5 months. Slump blocks have become detached from the upper part of the exposure to slide downslope. Some small scrub trees have also slumped.

The next roadcut occurs where the slope of the road breaks. About 5 feet of Peoria Loess containing the modern soil caps 2 to 3 feet of rubble, mostly country rock that does not appear to have moved far. It is a jumble of broken dolomite and fragmented chert with a few scattered erratics in a sandy, clay matrix. One large gabbro-type erratic, 0.8 by 1.0 foot in cross section, is exposed just above the uneven, broken bedrock surface. About 10 feet of Silurian bedrock, probably the Mosalem Formation, is exposed in the lower part of the cut.

0.0	39.95	Leave STOP 8 and CONTINUE AHEAD (east).
1.95	41.9	CAUTION: YIELD and TURN LEFT (north) at T-road intersection. The hamlet of Argo Fay is to the right at this intersection.
0.65	42.55	Begin gravel road travel and ascend the ridge.
0.85	43.4	This landscape has many similarities to the Galena area farther to the north. Ridge tops are capped with thin Silurian dolomite. Slopes are underlain by Maquoketa shale. Thin glacial deposits cover the bedrock strata.
1.0+	44.4+	CAUTION: unguarded cross road.


9
END
8
RADIO TOWER
ASHBY
28
29
32
33
34
27
0
½
1 mi
0
½
1
1½ km

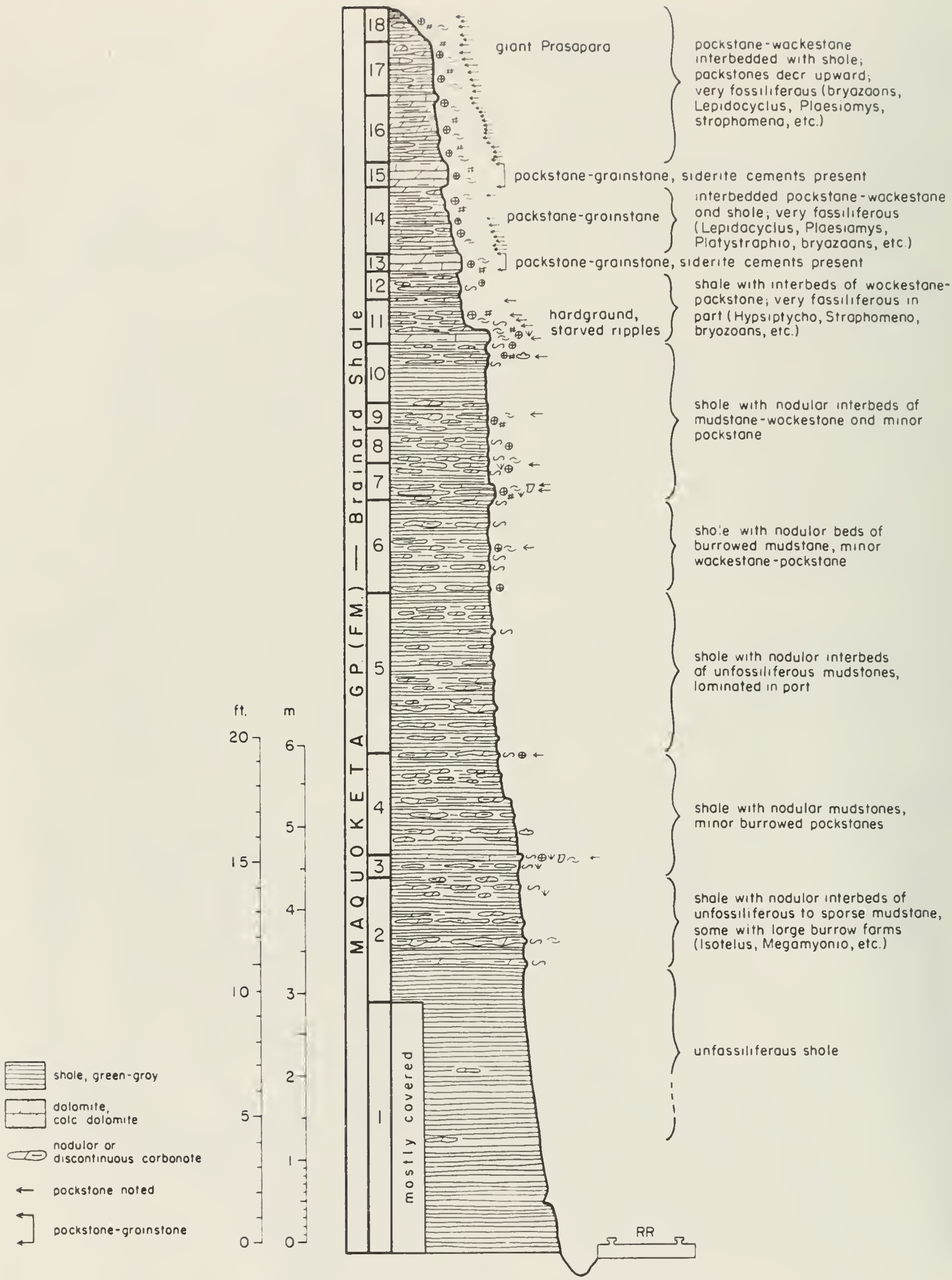


Figure 11 Graphic log of the stratagraphic section at Stop 9 (from Ludvigson and Bunker, 1988).

0.45 44.85+ CAUTION: PARK along the road shoulder--avoid the ditch. Do NOT park on the railroad overpass. The railroad tracks are private property and we do not have permission to go there. So DO NOT CLIMB DOWN to the railroad tracks.

STOP 9. Examination of the fossiliferous Brainard Shale (Maquoketa Group) on the high slopes above the BN RR cut (NW NW NW sec. 27, T24N, R4E, 4th P.M., Carroll County, Wacker 7.5-minute Quadrangle [42090A1]).

The exposure of the Ordovician Brainard Shale in this railroad cut is one of the best exposures of the formation in the Upper Mississippi Valley region (Ludvigson, 1988). A study of the sequence of sediments from the base upward in this exposure shows that deposition began in deep water, but conditions changed slowly and the water became shallower, or shoaled. This brought about a change in the texture and structure of the sediments as well as a change in the faunal types from bottom to top. The formation may be 75 to 100 feet thick where it is not deeply truncated by the sub-Silurian unconformity. The following graphic log (fig. 11) shows the relationships in this cut (Ludvigson, 1988).

End of ISGS Geological Science Field Trip to the Savanna area.

To leave, cross the narrow one-lane bridge. Go north 1/2 mile to a T-intersection. Turn left toward Wacker and Savanna. Turn right toward SR 78 and Mt. Carroll.

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PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moralnes**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

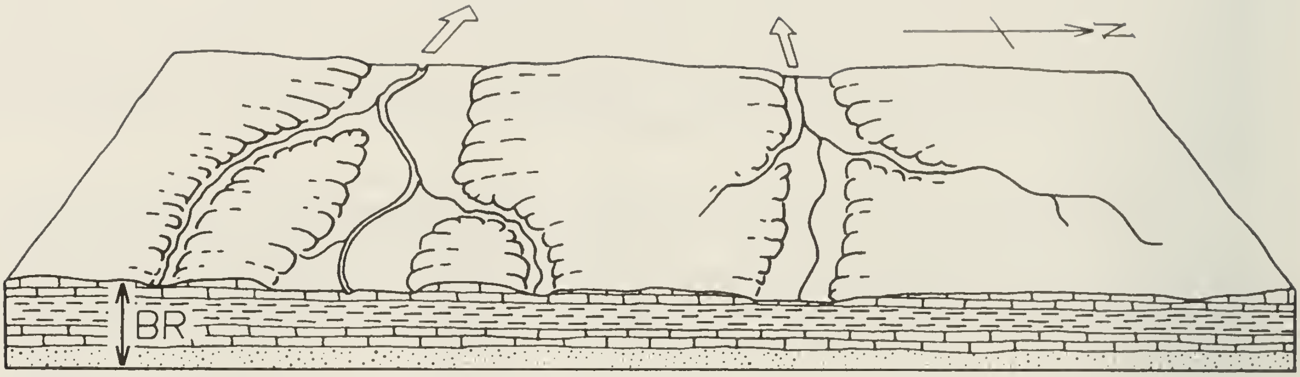
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

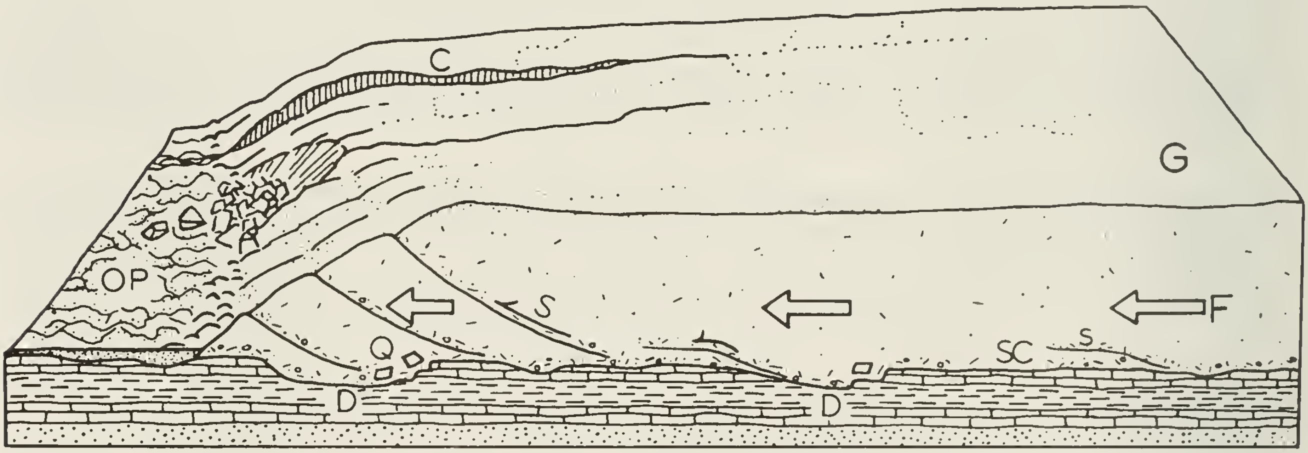
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

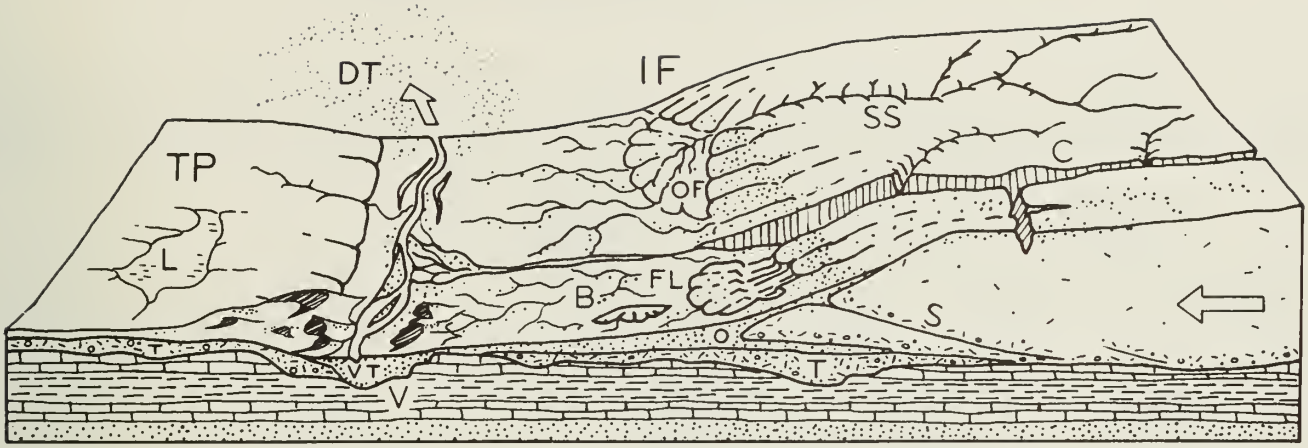
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



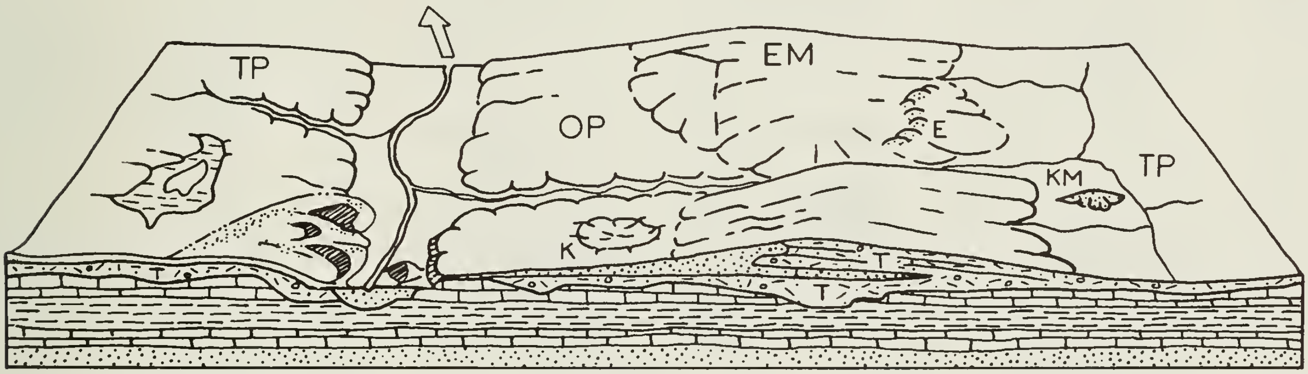
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

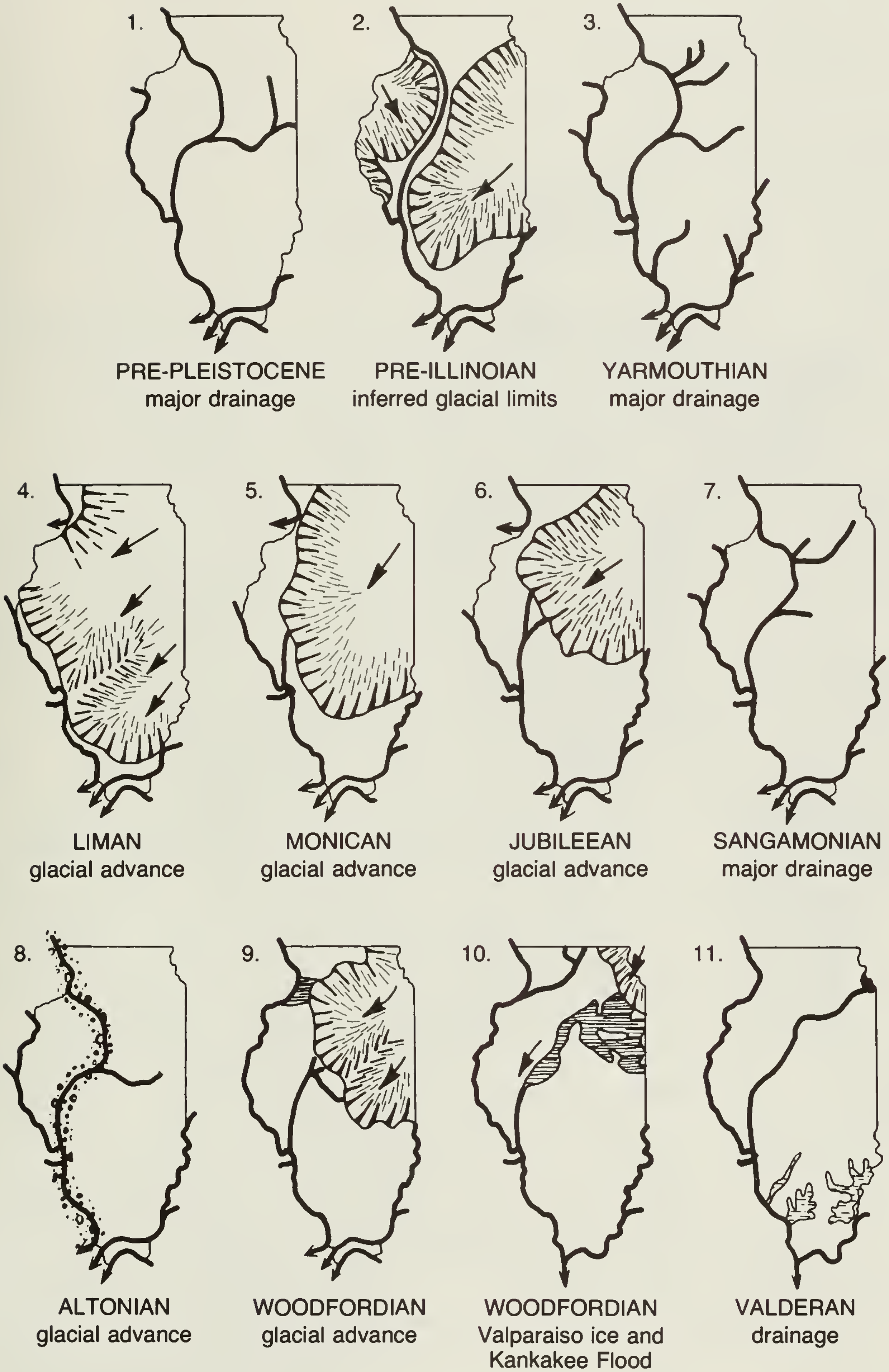
TIME TABLE OF PLEISTOCENE GLACIATION

			STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY			HOLOCENE (interglacial)	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
				10,000		
	Pleistocene		WISCONSINAN (glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
				11,000		
				Twocreekan	Peat and alluvium	Ice withdrawal, erosion
				12,500		
		late		Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
				25,000		
		mid		Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
				28,000		
		early		Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
				75,000		
			SANGAMONIAN (interglacial)		Soil, mature profile of weathering	Important stratigraphic marker
				125,000		
			ILLINOIAN (glacial)	Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
				Monican	Drift, loess, outwash	
				Liman	Drift, loess, outwash	
				300,000?		
			YARMOUTHIAN (interglacial)		Soil, mature profile of weathering	Important stratigraphic marker
				500,000?		
		Pre-Illinoian	KANSAN* (glacial)		Drift, loess	Glaciers from northeast and northwest covered much of state
				700,000?		
			AFTONIAN* (interglacial)		Soil, mature profile of weathering	(hypothetical)
				900,000?		
			NEBRASKAN* (glacial)		Drift (little known)	Glaciers from northwest invaded western Illinois
				1,600,000 or more		

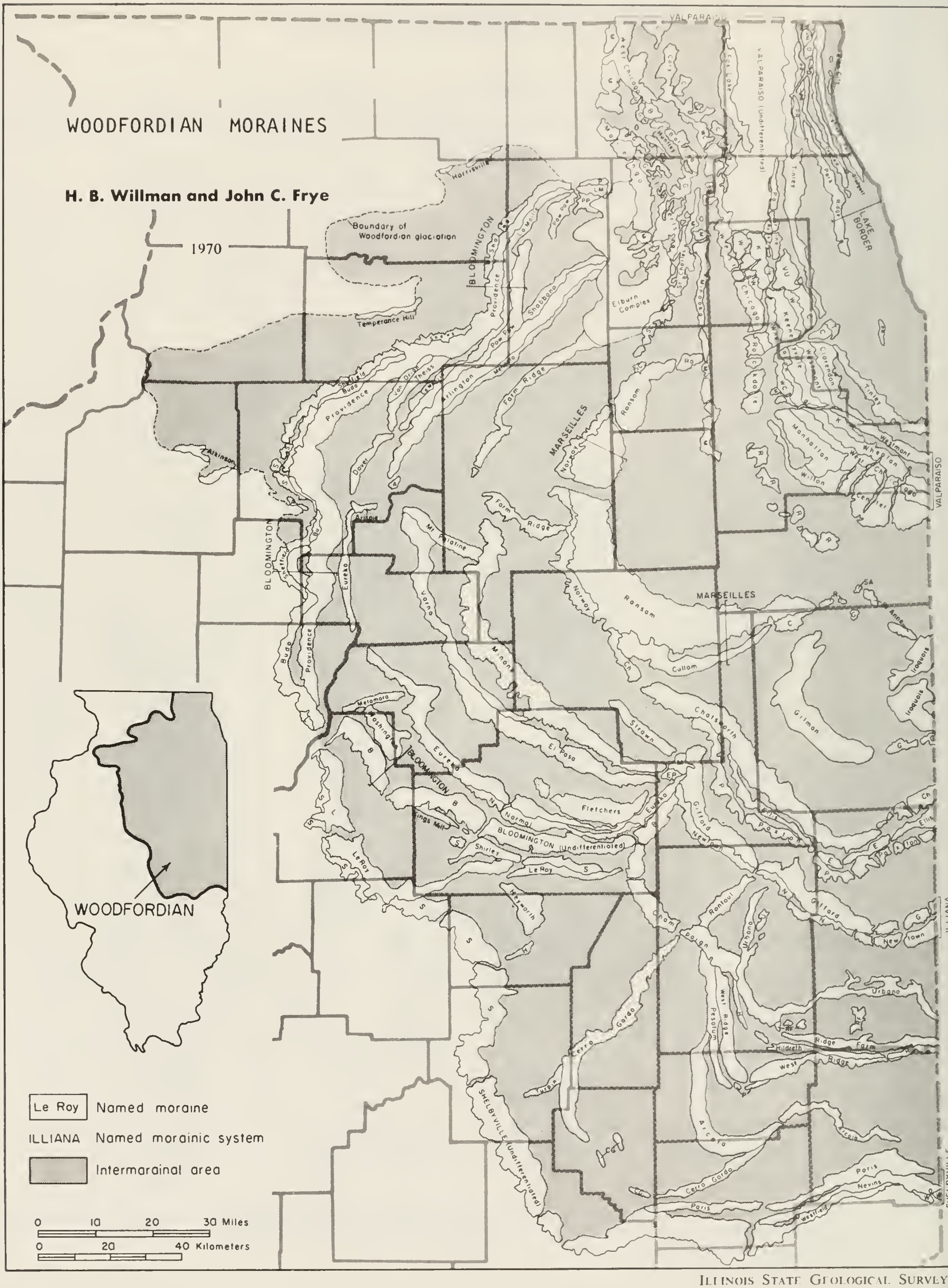
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)



WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers
VALPARAISO
LAKE BORDER
BLOOMINGTON
MARSEILLES
ILLIANA
SHELBYVILLE

ILLINOIS STATE GEOLOGICAL SURVEY

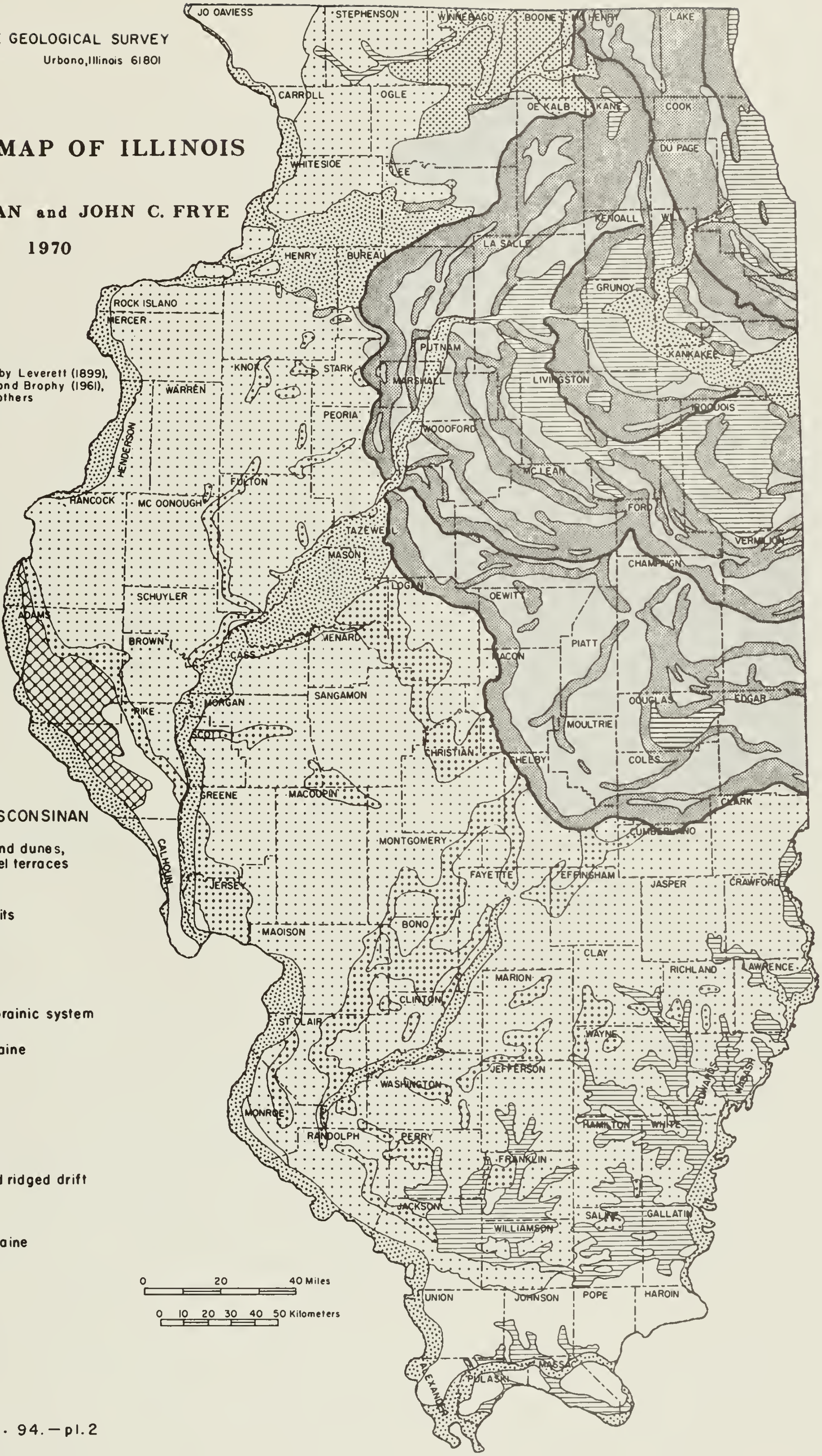
John C Frye, Chief   Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

Groundmoraine

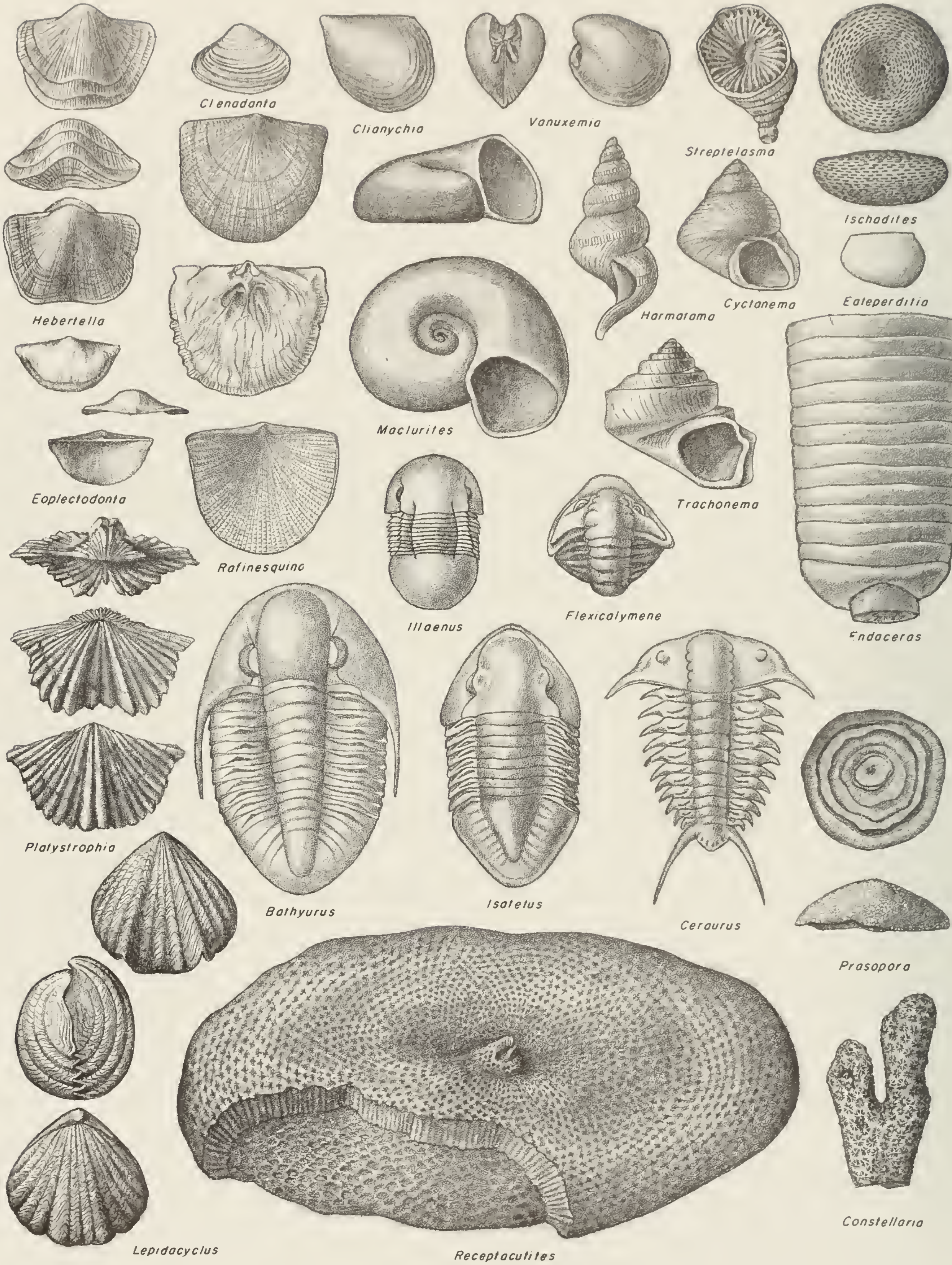
KANSAN

Till plain

DRIFTLESS

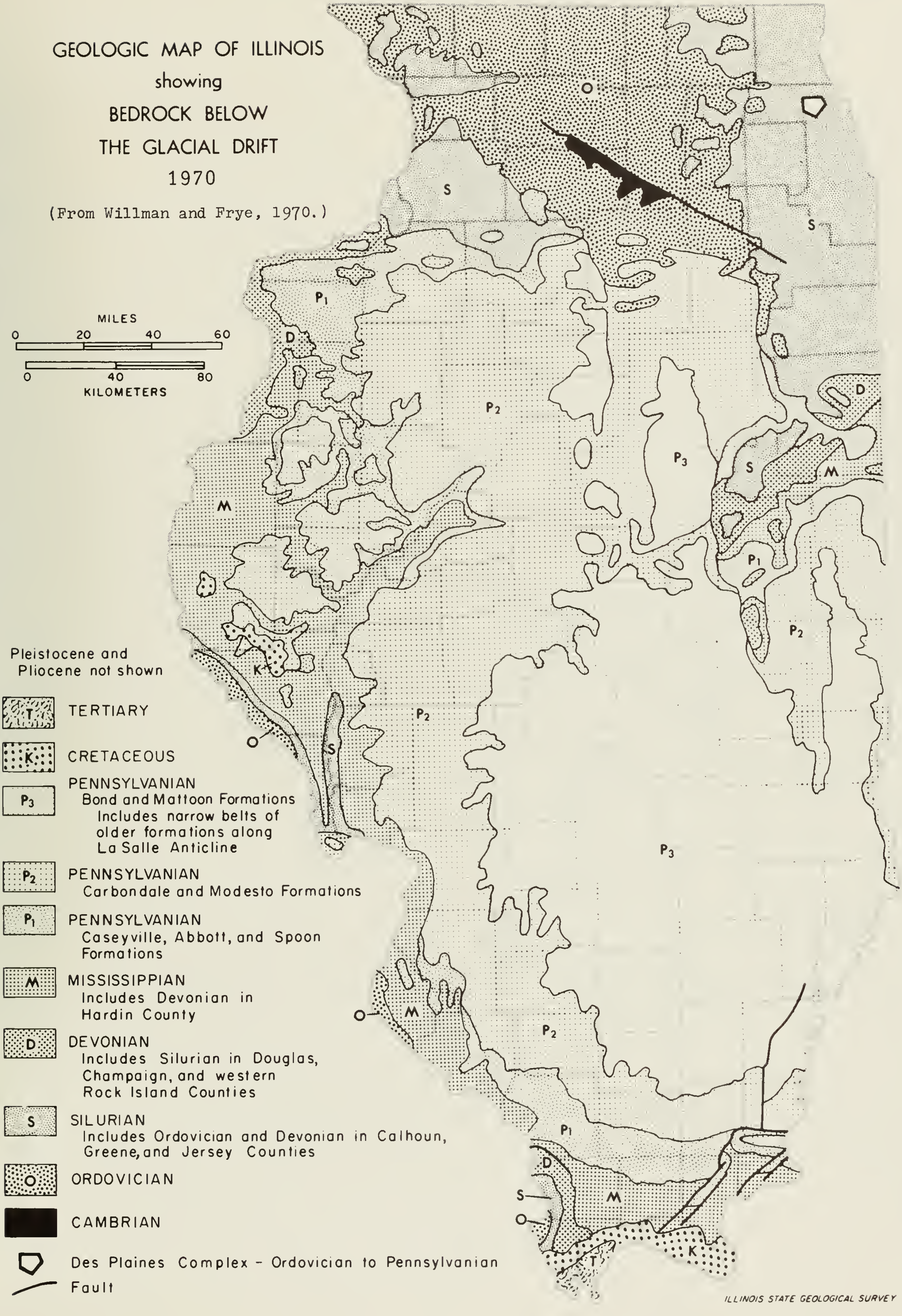
Modified from Bull. 94.—pl.2

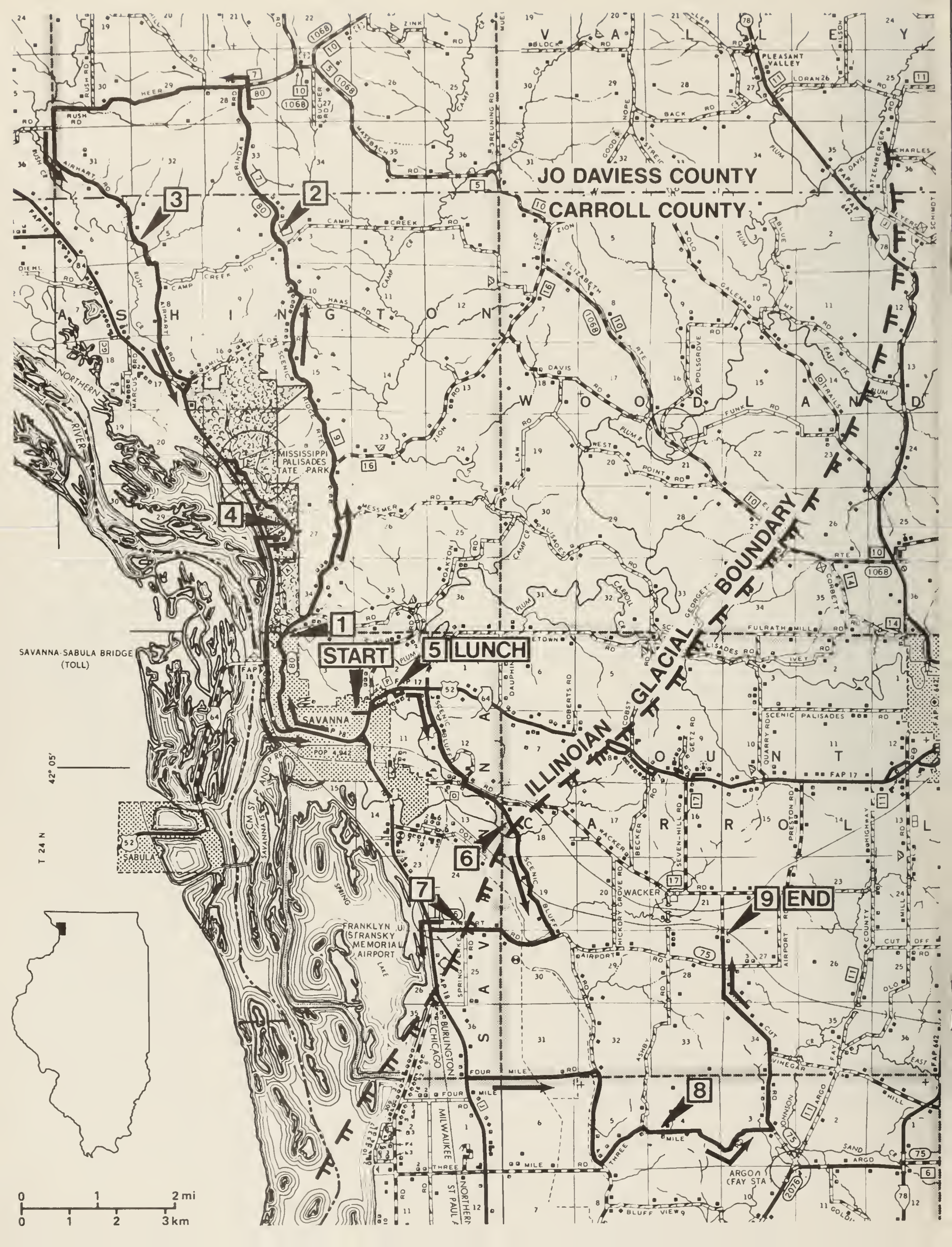
ORDOVICIAN FOSSILS



GEOLOGIC MAP OF ILLINOIS
showing
BEDROCK BELOW
THE GLACIAL DRIFT
1970

(From Willman and Frye, 1970.)




JO DAVIESS COUNTY
CARROLL COUNTY
ILLINOIAN GLACIAL BOUNDARY
WASHINGTON
WOODLAND
SAVANNA
MOUNT CARROLL
VALLEY
1
START
2
3
4
5 LUNCH
6
7
8
9 END
MISSISSIPPI PALISADES STATE PARK
SAVANNA-SABULA BRIDGE (TOLL)
SAVANNA
POP 4,942
SABULA
NORTHERN
RIVER
FRANKLYN STRANSKY MEMORIAL AIRPORT
PLEASANT VALLEY
WACKER
ARGO (FAY STA
CHICAGO BURLINGTON
MILWAUKEE ST PAUL
42° 05'
T 24 N
0 1 2 mi
0 1 2 3 km